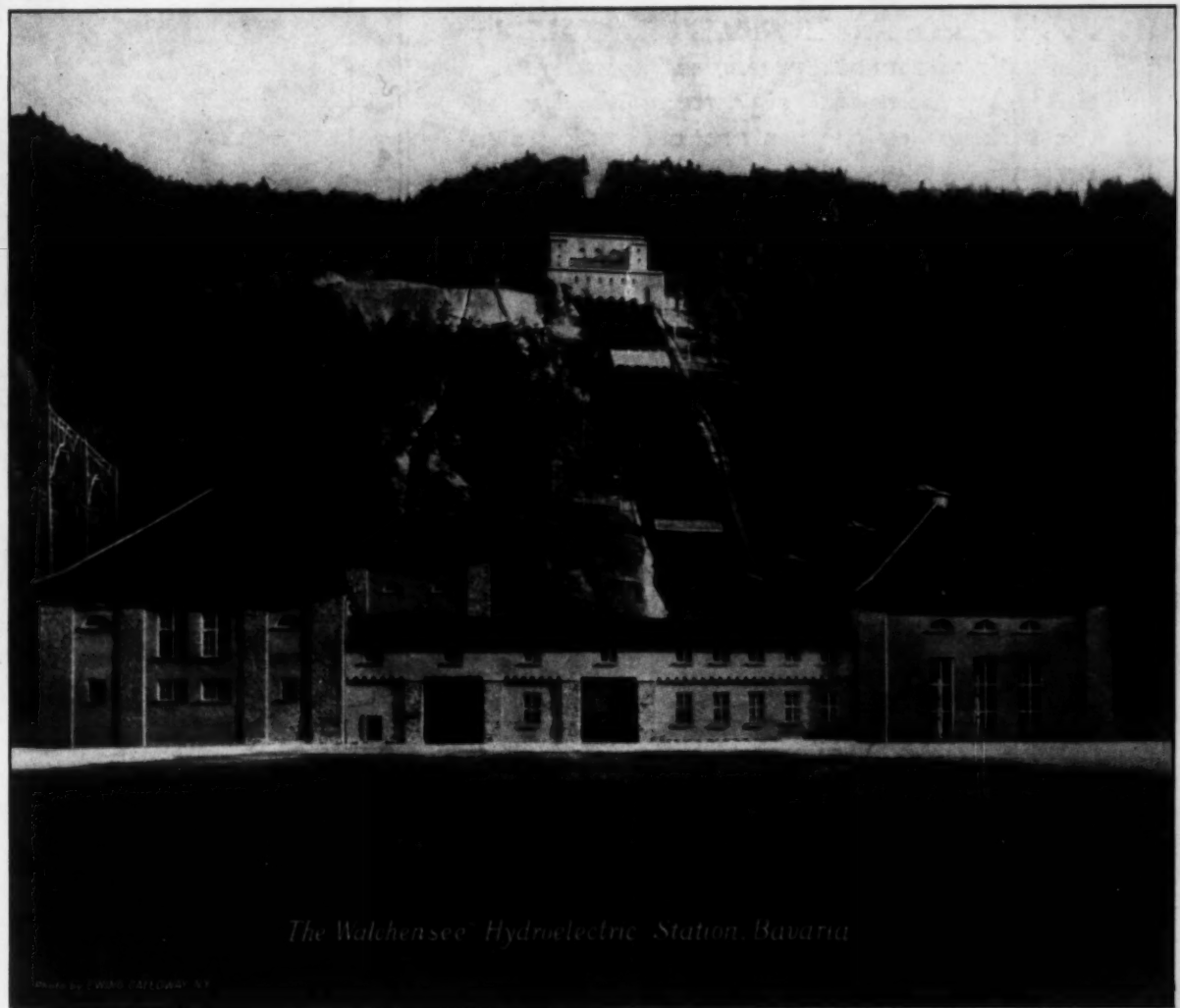
In Two Sections—Section One

MECHANICAL ENGINEERING



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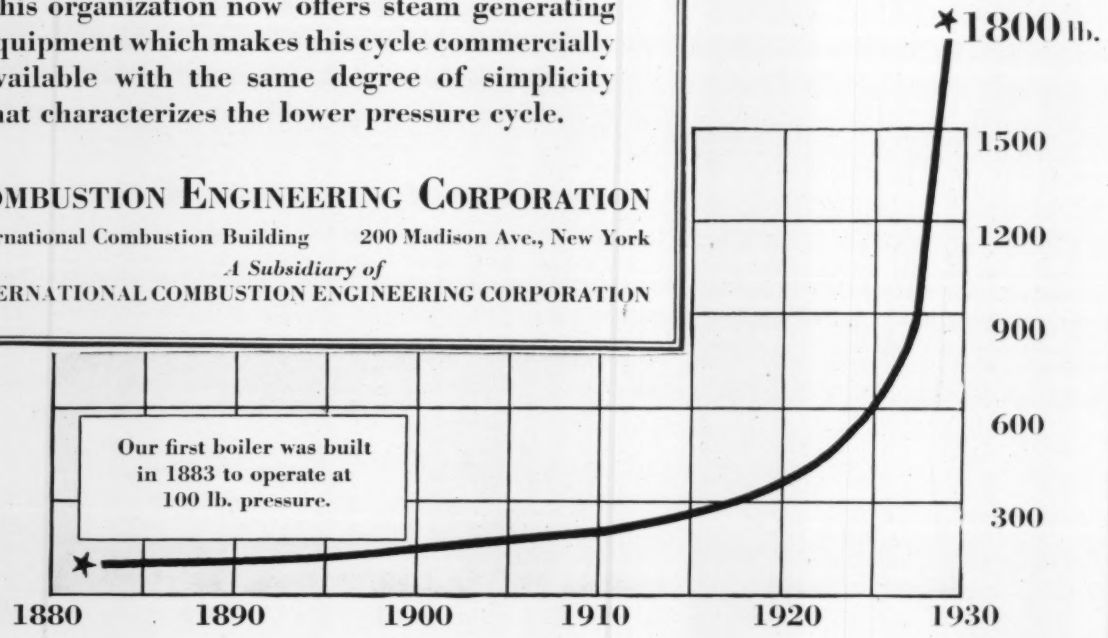

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Contributors to This Issue

L. P. Alford, vice-president of the Ronald Press, New York, is a graduate of Worcester Polytechnic Institute. From 1899 to 1907 he was connected first with the McKay Shoe Machinery Co. and then with the United Shoe Machinery Co. At the end of that period he became engineering editor of the *American Machinist*, and later editor-in-chief. From 1917 to 1920 he was editor of *Industrial Management*, resigning to become editor of *Management Engineering*, and later of *Manufacturing Industries*.

Mr. Alford is a past vice-president and member of the research committees of the American Engineering Council which were responsible for the reports on Waste in Industry, the Twelve-Hour Shift in Industry, and Safety and Production in Industry. He is a member of many scientific organizations.

J. E. Hannum, editor of the A.S.M.E. Engineering Index since 1927, was educated at Pennsylvania State College, from which he received the degrees of B.S. in industrial engineering and M.E. After graduation he was connected with the Skinner Engine Co., Erie, Pa., as machine-shop foreman, and later became an instructor in industrial management at Purdue University. His next position was with the Diamond Chain & Manufacturing Co. as efficiency engineer, from which he resigned to take charge of the industrial education of blinded soldiers at the Red Cross Institute for the Blind in Baltimore, Md. He has served as director of safety and production study for the American Engineering Council, as well as assisting in the studies on "Waste in Industry" and "Recent Economic Changes."

Charles L. Lawrance, president of the Wright Aeronautical Corporation and director of the Aeronautical Chamber of Commerce, is well known as a leader in the development of aerial navigation and for his outstanding work in the perfection of engines used for aviation purposes, particularly in the development of air-cooled aircraft engines. Mr. Lawrance was graduated from Yale University in 1905, and later attended the École des Beaux Arts of Paris for three years, then returning to New York to engage in the practice of engineering. With the outbreak of the war he was assigned by the Navy Department to carry out extensive research work in connection with aircraft-engine development. One of his notable contributions to the progress of aviation is the Wright Whirlwind 200-hp. air-cooled engine, which made possible the world-famed Lindbergh, Byrd, and Chamberlin transatlantic flights.

B. R. Van Leer, assistant secretary of the American Engineering Council, upon his graduation from Purdue University in 1915, joined the faculty of the University of California, as assistant professor of mechanical engineering. When the United States entered the War he enlisted in the engineering corps of the Army and served overseas, being promoted to the rank of captain. He was cited for bravery and was also awarded the Croix de Guerre by the French Government. Mr. Van Leer was the recipient of one of the John R. Freeman Traveling Fellowships and spent a year in Europe studying the great hydraulic laboratories there. His article in this issue is the result of that study.

L. W. Wallace has been executive secretary of the American Engineering Council since 1921. He received the degree of B.S. in 1903 from the Agricultural and Mechanical College of Texas and of M.E. in 1912 from Purdue University. From 1906 to 1917 he served on the faculty of Purdue as assistant professor and later as professor of railway and industrial management. For the next two years he was assistant general manager of the Diamond Chain & Manufacturing Co., Indianapolis, Ind., resigning to become director of the Red Cross Institute for the Blind in Baltimore, Md., where men who were blinded in the war were trained in suitable industries.

Mr. Wallace is president of the Eyesight Conservation Council of America, and since 1925 has been a member of the Committee on Patent Office Procedure. He served for three terms as president of the Society of Industrial Engineers, and is a member of many scientific and technical organizations.

Prof. Dr. C. Von Dobbeler of Karlsruhe, Germany, writes in this issue on the advantages of the German series of preferred numbers in the establishment of series of sizes of finished products.

K. Gramenz, author of the article on "Limitations of Standardization," is chief engineer of the German Standards Committee in Berlin.

This Month's Cover is a photograph of the largest hydroelectric station in Germany, which has been described as the backbone of the system of interconnected steam and hydroelectric plants in Bavaria. The station is located between two lakes, the Walchensee and the Kochelsee about 200 meters below it. The water drawn from the Walchensee passes through a tunnel in the Kesselberg mountains which separate the two lakes, and then descends by way of the pipes shown in the photograph to the power station. The water leaving the turbines flows through a short tailrace into the Kochelsee. The turbine room contains 8 main generating sets with an aggregate capacity of 123,000 kva. and two auxiliary 1100-kva. machines. The illustration is of particular interest in connection with Mr. Van Leer's article.

MECHANICAL ENGINEERING

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A Basis for Evaluating Manufacturing Operation

Proposed Basis and Methods for Evaluating Certain Factors in the Operation of Manufacturing Establishments, and Consideration and Interpretation of These Factors as Revealed by Analysis of Manufacturing Records and Statistics

By L. P. ALFORD[1] and J. E. HANNUM,[2] NEW YORK, N. Y.

THIS paper is divided into two parts. The first is a presentation and discussion of a basis and methods for evaluating certain factors in the operation of manufacturing establishments. The second is a consideration and interpretation of these factors as they are revealed by the analysis, on the basis proposed, of a considerable volume of manufacturing records and statistics. The authors' purpose in undertaking this study was to develop an analytical method, but the significance of the factors of operation as discovered seems to warrant devoting the larger amount of space to them.

PART I—A BASIS AND METHODS FOR EVALUATING CERTAIN FACTORS IN THE OPERATION OF MANUFACTURING ESTABLISHMENTS

With very few exceptions the factors that have been proposed and used to evaluate and compare the results of the operations of manufacturing companies are simple ratios or percentages. The efficiency percentage and labor-turnover percentage of management engineers, the financial ratios applied by bankers, and the operating ratios that have been ably presented and fully discussed in meetings of this Society,[3] are examples of these simple factors.

However, none of these factors is entirely free from question as to the value of its indication. Some are in continual controversy as to the method of computation, and others have had but little practical application. This situation encourages renewed attack on the general problem, for no argument is needed to convince any one concerned with industrial operation, whether he be engineer, executive, or banker, as to the possible usefulness of a generally acceptable basis and method for comparing the relative success or failure of an industrial enterprise, and for indicating the probable nature of future performance.

At the outset of the study which has yielded this paper, the authors reached the conclusion that a group of compound units or factors built up from a common base would be more useful than any group of simple ratios or percentages. The question then arose, What base factor shall be selected? Seemingly, it must be:

Measurable by an established unit
Universal in use in industry
Easy to handle in computation
Influential in its effect on industrial operation.

One example of such compound factors is found in the accepted units for indicating industrial-accident performance. The base is the man-hour. Accident frequency is expressed by the number of lost-time accidents per 1,000,000 man-hours worked; accident severity is expressed by hours lost from employment per 1000 man-hours worked. Other examples of such a base are the passenger-mile and the ton-mile as used in railroad operation.

One requirement of such a base factor as given above is that as changes take place in operation, it must exercise a major influence on the results. This seems to limit selection to a production factor.

It is evident that few production factors can be identical in any two cases. Plant sites, though in the same locality, have different characteristics. Buildings differ in plan, construction, and arrangement. Equipment, even to manufacture the same product, is not necessarily the same. Processes, operations, and methods are never just alike. Materials, though bearing the same name, vary as to properties and characteristics; products, though of the same kind, differ as to design, workmanship, and quality. Management and operating methods are never just the same.

In the preceding statement, however, one production factor is not mentioned. This is human effort. Workers are much the same wherever found in industry. Some sixty per cent of all those employed in manufacturing are unskilled or little skilled. Industrial labor is mobile, constantly changing from job to job. Labor-turnover records are evidence of this mobility, and lead to the conclusion that a certain worker may be in one industry today, in another tomorrow, and in a third a few months later on. Only a few hours, or a few days, of training are required to bring a worker up to a satisfactory rate of production on most specialized manufacturing operations. The Segur law of motion time indicates that on standardized manual factory operations any expert worker has the same time capacity for doing work as another.

The indications, therefore, are that the production factor—human effort as applied in manufacturing—would have many of the characteristics of a constant if it were possible to express it by a measured unit. This we cannot do today. We can only apply

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[2] Editor, The Engineering Index Service. Assoc-Mem. A.S.M.E.
[3] "Measurement of Management," by Joseph W. Roe, Trans. A.S.M.E., vol. 45 (1923), p. 825.

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a time measurement, assuming that on the average an hour of work in one industry, or in one plant, is the substantial equivalent in human effort (mental, manual, or combined) of an hour in another industry or plant.

The time factor therefore satisfies the first and second requirements of a base factor, for it is measurable in accepted units and is universally used in industry. Working time is everywhere expressed in subdivisions or multiples of the hour.

The third requirement is also satisfied, for the number of hours worked in any period—day, week, month, quarter, half-year, or year—are immediately available from payroll records, and are easily handled in computation as will be shown later.

The fourth requirement is that of influential effect. The factor we are considering is human effort or labor, expressed on a time basis. There is some evidence that, of all the production factors, labor has the greatest effect on output for equal percentage changes.

Professors Charles W. Cobb and Paul H. Douglas have established the ratios of the effect of labor and fixed capital on production from a study of the manufacturing production of the United States from 1899 to 1922. They impute three-fourths of the increase in production for that period to labor and one-fourth to fixed capital. By fixed capital is meant the investment in buildings, equipment, and machinery.

In other words, a certain percentage change in the labor factor alone has *three* times the effect on production of the same percentage change in the fixed capital factor alone.

From still another point of view, the labor-effort factor occupies a position of major importance. Throughout the sweep of the development of manufacturing in America, and particularly since 1900, which marks the time when handicraft production disappeared and modern management began to rise, cost reduction has had a prominent place in every manufacturing program. Improvements have been made in the utilization of all the factors of production, resulting in shorter times for material in transit to the factory, shorter times for machining and processing, shorter times in stock- and stores-room storage, and shorter times en route to the customer. In fact, this increase in pace of manufacturing and the control of the flow of work required to bring it about mark what is probably the most important economic decade. Throughout, emphasis has been on the labor time factor. These industry-wide attempts to reduce time as a production factor again suggest its importance as a basic unit in analyzing and comparing manufacturing operations.

Engineers, especially members of this Society, have been the pioneers and leaders in this effort to reduce time and cost and to conserve human effort in manufacturing. In fact, their teachings and actions have given us a new societal doctrine: the preciousness of human effort. Although this has had its rise in self-interest rather than in altruism, it seems worthy to be placed beside two other great doctrines of organized society: the sacredness of human life; the dignity of human labor. The first is ours as a heritage from distant ancestors; the second was established in this country by our immediate forefathers; the third, which we are now adding, we owe to our engineering associates of the past quarter-century. This new doctrine imposes the obligation, on the one hand, to conserve human effort and prevent its waste, and, on the other, to use it with the greatest of managerial skill and effectiveness in doing the work of industry.

Having established the time factor as one that satisfies the requirements of a base for a group of compound units, it is necessary to determine the unit in which it shall be expressed. One thousand man-hours, conveniently named the "kilo man-hour" has been taken as this unit. Its use yields quantities for the compound units ranging in most cases from two to four significant figures, and therefore of a kind easy to handle and memorize.

From this base factor, the kilo man-hour, numerous factors of industrial operation can be developed. Those given at the top of page 183 are probably the most important, although they do not exhaust the possibilities.

It is self-evident that many of these compound factors can be separated into component elements for the purposes of comparison and analysis, but all on the base of the kilo man-hour.

It is evident, likewise, that the results of manufacturing operation expressed in terms of these compound units can be used to compare the period-to-period performance of a single industrial establishment, or to compare the relative achievements of two or more concerns in the same line of industry, or, even as regards certain selected factors, to compare the relative performance of concerns in different lines of manufacturing.

Management, most elusive of all factors in evaluating a financial situation, may at last be measured as a result of the studies of Messrs. L. P. Alford and J. E. Hannum.

Kilo man-hours is an index that may come to mean as much to the financial community as net quick assets or inventory turnover.

By utilization of this formula come revelations which are not short of astounding. Of the 42 industries analyzed the average variation between the maximum and minimum producers in the same industry is 13.25 times in value of product.

Stockholders and investors will thus find a light for the protection of their capital thrown into a hitherto darkened area. The nation will find another means of increasing its operating efficiency through the correction of control demonstrated relatively unproductive.

Kenneth C. Hogate,
Managing Editor, "The Wall Street Journal"

PART II—CONSIDERATION AND INTERPRETATION OF FACTORS DISCUSSED IN PART I AS REVEALED BY ANALYSIS OF MANUFACTURING RECORDS AND STATISTICS

A considerable volume of records, statistics, and data on manufacturing operations was available to the authors for study and analysis in preparing this paper. The Safety and Production Report of the American Engineering Council, published early this year, gives a large number of production rates per man-hour expressed in physical units. These factors are for the year 1925. The published reports of the United States Bureau of the Census and of the United States Bureau of Mines for the year 1925, taken together, give statistics for the number of employees, physical production, wages, cost of materials, value added by manufacture, and value of products for the manufacturing and mining industries. These reports form the principal source of information used in this study. Wherever other data are used the origin is indicated.

It is quite evident that this study could not have been made at all except for the production rates in man-hours obtained

Factor	How Expressed
Productivity	Physical volume of product per kilo man-hour
Labor permanence	Number of workers employed per kilo man-hour
Fixed capital investment:	
Buildings	Investment in dollars per kilo man-hour, or Square feet of floor area per kilo man-hour
Machinery	Investment in dollars per kilo man-hour
Primary power	Horsepower utilized per kilo man-hour
Industrial accidents:	
Frequency	Number of lost-time accidents per 1000 kilo man-hours
Severity	Number of working hours lost per kilo man-hour
Costs:	
Wages	Dollars per kilo man-hour
Material cost	
Prime cost	
Overhead charges	
Manufacturing cost	
Profit:	
Manufacturing	Dollars per kilo man-hour
Net	
Selling price	Dollars per kilo man-hour

from the American Engineering Council's report. Once these rates were expressed in kilo man-hours, easy, though extensive, computations permitted the tabulation of the statistics of Government reports on this basis.

DATA USED IN AUTHORS' STUDY

American Engineering Council Data. From the Safety and Production Study of the American Engineering Council the following information was secured for some 13,000 plants:

Total quantity of product turned out in the year 1925.

Average number of employees engaged in plant operation and maintenance for the same year.

Total number of man-hours worked by all employees engaged in plant operation and maintenance for the same year.

United States Bureau of the Census and United States Bureau of Mines Data. From the reports of these two Federal bureaus, information was obtained as follows:

Number of wage earners, that is, factory and industrial employees, averaged for the year 1925.

Total annual quantity of product turned out.

Total compensation of wage earners, including those employed on a piece-price basis.

Cost of materials actually used during the year. This covers fuel purchased, electric current, factory or shop supplies, and containers, as well as materials which formed a constituent part of the product.

The value created by the manufacturing process, usually called "value added by manufacture." This is calculated by deducting the cost of materials used from the value of the products.

Value of products, which represents the selling value at the factory of all products manufactured during the year. This amount may differ from the value of the products actually sold, depending upon the increase or decrease in the finished product inventory.

Computed Values. From the information indicated in the preceding nine items the following factors were computed:

The rate of production, that is, the rate for the individual company, which was obtained by dividing the quantity of product by the number of man-hours worked and reducing the result to the common basis of the kilo man-hour.

The weighted mean rate of production, which is the arithmetical mean rate of production for a group of companies manufacturing the same product. This was obtained by dividing the total quantity of product for the group by the total number of man-hours worked for the group.

Deviation of production rate from weighted mean, which is the difference between the production rate of each company and the weighted mean rate for the group.

Mean deviation of production rates, which is the sum of the individual company deviations divided by the number of companies.

Coefficient of variation of production rates, which is the mean deviation divided by the weighted mean.

Ratio of maximum to minimum production rates, obtained by dividing the highest individual company rate of production in a group by the lowest individual company rate in that same group.

United values, which were computed on the kilo man-hour basis for wages, cost of materials, prime cost, value added by manufacture, and value of product.

The tabular results of the study are presented in five summary tables and eighty which present detailed information for product groups.

From the nature and origin of the data, and the methods of classification employed, the authors attach but little significance to the actual numerical values given in the tables. The important features rather seem to be the relationships and relative positions in sequence of the various factors and industrial groups with which they are associated.

INTER-INDUSTRY RELATIONSHIPS

The spread of the information studied is indicated by Table 1, which gives production equivalents for 66 industries; that is, it gives the output of goods expressed in physical units per thousand factory man-hours worked. The number of industrial plants that contributed information to this summary is 13,385; the number of employees represented is 1,683,221; the number of factory man-hours worked during 1925 by these employees is 3,470,152,844. The significance of these totals is to show the extent to which the kilo-man-hour analysis has been applied.

A few of the product groups which were studied are listed in the first column of Table 2. In all there are 100 of these, and for each of 66 of them the ratio of its production of goods in 1925 to the total produced in the United States for the same year is given in the original table of which Table 2 is an abridgment. The highest of these ratios is 88 per cent, and the lowest about one per cent; 29 are over 10 per cent.

Thus the credibility of different groups of results may vary due to the proportionate size of the group, but the authors believe that the general conclusions which the data indicate are not weakened by these variations in group proportions.

The comparisons between industries are given in these two table, Tables 1 and 2. As regards the production rates, they are possibly of more interest than significance. Yet a few relationships may properly be pointed out. The production rate of bituminous coal is 560 tons, while that of anthracite is 266 tons, or less than one-half. The production rate for boilers and tanks is 12.05 tons, for agricultural implements 16.65 tons, and for sheet-metal products 17.30 tons. The last rate is the highest for the machinery-building and metal-working groups. The lowest rate among these groups is for machine tools, 2.70 tons, and this is less than one-half that for special machinery, which is 5.15 tons. Another low production rate is that of engines, turbines, and pumps, namely, 3.17 tons.

The comparisons of values per thousand factory man-hours given in Table 2 are worthy of more extended consideration. The significant column in this table is the last, which gives

selling values at the factory. It shows the sale value of product, measured in dollars per thousand factory man-hours worked, for various product groups.

The spread of these selling values ranges in round figures from $550 to $10,800 (in the complete table), or in the ratio of 1 to 19. Industries which during the past few years have been prosperous are in the upper part of this list; and others which have become notorious because of their business troubles are in the lower part.

Seemingly a high selling value of product per thousand factory man-hours worked indicates prosperity, and a low value for this same factor tends toward business distress. This indication is supported by a consideration of net profit on this same basis. The tabulation at the top of the following page compares the percentages of net profit earned by seven major industrial groups with the selling values of product, taken from Table 2, for various constituent product groups in the major industrial groups. The profit figures are taken from a paper presented to the National Association of Cost Accountants by John T. Madden, Dean of the School of Commerce, New York University.

One more inter-industry relationship requires consideration: the relation between managerial effort and selling value of product. It may be assumed as substantially true that managerial effort and supervisory costs of man management vary directly with the number of man-hours worked. This being so, it appears that the managements of some industries exert far more effort in man supervision for, say, $1000 worth of product than others. For example, this managerial ratio for writing paper and rubber tires is 5 to 1; for leather shoes and lead products, 5½ to 1; for gray-iron castings and automobiles, 6 to 1; for candy and soap, 6½ to 1; for cotton fabrics and paint, 7 to 1; and for machine tools and flour, 7 to 1. These are but a few of such ratios that may be computed from inspection of the data of Table 2.

TABLE 1 PHYSICAL VOLUME OF PRODUCTION PER 1000 FACTORY MAN-HOURS FOR 66 INDUSTRIES

Industries	Number of companies	Number of employees	Number of factory man-hours worked	Production rate per 1000 factory man-hours
Chemical industries	30	14,730	36,755,587	28.93 short tons
Acids and heavy chemicals	7	6,383	16,153,088	34.1 short tons
Explosives	16	3,465	8,747,393	34,200 lb.
Coal-mining industries	7,470	748,805	1,161,791,722	501 tons
Anthracite	326	160,316	233,484,272	266 tons
Bituminous	7,144	588,493	928,377,450	560 tons
Coke industries	154	20,451	51,947,803	854 tons
Beehive coke	99	6,450	10,238,687	1005 tons
By-product coke	55	14,011	41,709,116	816 tons
Iron and steel industry	36	48,889	138,712,045	37.5 long tons
Fabrication of steel	6	3,004	8,065,790	45.15 long tons
Skelp, plates, and sheets	8	8,634	23,637,192	56.5 long tons
Structural shapes	6	3,388	9,654,736	32.8 long tons
Tubing	5	8,062	21,668,941	46.2 long tons
Leather-shoe industry	6	6,534	16,898,800	406 pairs
Machine-building and metal-working industries	224	172,308	414,439,963	10.6 tons
Agricultural implements	5	2,677	6,650,821	16.65 tons
Automobiles	12	151,447	382,211,176	9.08 cars
Automobile parts	5	1,367	3,630,696	12.85 tons
Boilers and tanks	10	4,064	10,079,771	12.05 tons
Bolts, nuts, and rivets	6	4,419	10,895,000	16.60 tons
Brass, bronze, and copper	14	23,510	61,658,572	8.15 tons
Cast-iron enameled ware	5	8,664	20,423,347	8.08 tons
Electric machinery, apparatus and supplies	8	14,777	36,053,558	6.03 tons
Engines, turbines, and pumps	5	2,471	6,162,638	3.17 tons
Forgings	11	5,260	12,936,999	16.64 tons
Gray-iron castings	16	9,409	19,167,215	14.05 tons
Hardware	15	8,164	20,008,959	14.20 tons
Hoisting and conveying machinery	5	2,643	6,491,829	7.46 tons
Machine tools	8	2,276	5,308,719	2.70 tons
Malleable-iron castings	11	4,107	9,563,424	6.92 tons
Non-ferrous castings	12	4,170	10,037,141	6.41 tons
Oil-well equipment	5	2,035	5,177,482	7.80 tons
Railroad accessories	13	15,679	36,205,412	15.50 tons
Sheet-metal products	10	8,261	20,566,387	17.30 tons
Special machinery	8	3,098	4,801,704	5.15 tons
Springs	7	1,684	4,393,941	13.50 tons
Steel castings	15	8,485	21,803,482	14.95 tons
Valves and fittings	13	10,215	21,260,800	7.00 tons
Wire products	10	12,143	30,904,117	8.71 tons
Manufactured gas	37	23,086	51,591,750	2260 M. cu. ft.
Manufactured ice	6	1,061	2,648,845	910 short tons
Metal-mining industries	2,783	123,128	292,251,000	523 short tons
Copper mining	271	32,477	83,650,000	594 short tons
Gold, silver, and miscellaneous	2,097	29,718	71,350,000	146 short tons
Iron mining	104	36,629	80,500,000	725 short tons
Lead and zinc mining	87	12,734	30,250,000	830 short tons
Non-metallic minerals	224	11,570	26,550,000	344 short tons
Paper and pulp industries	50	28,837	76,703,789	31.0 short tons
Boxboard	5	3,303	8,826,036	27.21 short tons
Corrugated cartons	5	806	2,079,849	63.50 short tons
General	24	12,551	34,801,749	29.8 short tons
Wrapping paper	6	1,477	3,834,587	19.7 short tons
Petroleum products	7	10,880	28,378,101	1610 barrels
Portland cement	120	35,000	97,414,794	1484 barrels
Quarrying industries	1,660	77,609	188,050,000	525 short tons
Granite	...	12,153	28,250,000	244 short tons
Limestone	...	48,391	119,700,000	635 short tons
Marble	...	5,764	16,000,000	32.3 short tons
Sandstone and bluestone	...	5,430	11,900,000	328 short tons
Trap rock	...	5,871	12,200,000	956 short tons
Textile industries:				
Bleached, dyed, and printed cotton goods	5	5,248	12,808,763	28,800 yd.
Cotton fabrics	13	11,850	31,137,347	2,200 lb.
Hosiery	7	2,698	6,386,701	349 doz. pairs
Wood industries:				
Lumber	34	14,103	35,684,551	59,000 ft. B.M.
Millwork	7	1,238	3,411,496	19,500 ft. B.M.
Total	13,385	1,683,221	3,470,152,844	

Intra-Industry Relations

That variations exist between the effectiveness of operation of plants in the same industry is well known. The extent of such variations measured in physical output per thousand man-hours is indicated in another table in the complete paper in which are given for each of 42 product groups the ratio of maximum to minimum production rates (ranging from 1.54 to 91) and the coefficient of variation (ranging from 13 to 135 per cent). Even allowing for variations in volume and quality of products, the lesson of this table is plain and inescapable. Many plants in every line of industry need upgrading to bring their production per man-hour up to the high level already attained in that industry.

Economic Considerations

Members of this Society were the first to declare, in the face of much objection and opposition, that low manufacturing costs accompany high wages. The data in Table 3 indirectly support this economic truth. High wages are seen to accompany high values added by manufacturing and high selling values of product. Here again the arrangement of product groups is similar to that noted by preceding analyses, with automobiles, manufactured ice, and explosives at the top, and leather shoes, cotton fabrics, and cast-iron pipe at the bottom. It appears that certain industries are caught in a vicious circle of low wages and inefficiency.

Much discussion has been given to the question of relative efficiencies of large and small plants. Another table in the

Industrial group	Percentage of net profit, 1925	Constituent-product groups	Selling value of product per 1000 man-hours
Leather	3.26	Leather shoes	$1120
Textiles	4.11	Yarn and thread	548
		Knitted underwear	1115
		Cotton fabrics	1320
		Rope and twine	1330
		Hosiery	1390
		Knitted sweaters	1447
Lumber	5.38	Sash and doors	584
		Millwork—doors	1160
		Furniture	1440
		Woodenware	2070
		Lumber	2190
Paper	6.97	Writing paper	1000
		Book paper	1950
		Boxboard	2180
		Wrapping paper	2190
		Paper and pulp	2825
		Newsprint	3020
Printing	7.73	Commercial printing	2370
Rubber	8.98	Rubber tires	5080
Chemicals	10.15	Explosives	3950
		By-product coke	4700
		Lead products	6030
		Petroleum products	7570
		Soap	7990
		Paint, varnish, and lacquer	9400

TABLE 2 VALUES OF PRODUCT PER 1000 FACTORY MAN-HOURS FOR CERTAIN INDUSTRIES

Industries	Ratio of compiled to census production, per cent	Number of companies†	Number of employees	Value per 1000 man-hours
Paint, varnish, and lacquer	10.04	4	1,154	$9400
Soap	41	...	2,458	7990
Petroleum products	17	7	10,880	7570
Automobiles	83	12	151,447	6410
Lead products	41.7	3	441	6030
Rubber tires	3.9	...	2,168	5080
Beehive coke	*	99	6,450	4725
Coke industries	*	154	20,451	4710
By-product coke	*	55	14,001	4700
Manufactured ice	6.2	6	1,061	4240
Explosives	54	16	3,465	3950
Newsprint	44.2	3	6,158	3020
Paper and pulp	23.6	50	28,832	2820
Commercial printing	*	3	587	2370
Lumber	5.7	34	14,103	2190
Wrapping paper	5.8	6	1,477	2190
Boxboard	10	5	3,303	2180
Woodenware	*	3	274	2070
Book paper	6.5	3	2,332	1950
Knitted sweaters	1	3	272	1447
Furniture	*	19	5,443	1440
Hosiery	2.1	7	2,698	1390
Machine tools	*	5	2,374	1390
Rope and twine	1.8	...	600	1330
Cotton fabrics	3.3	13	11,850	1320
Millwork—doors	8	3	2,186	1160
Leather shoes	2.1	6	6,534	1120
Knitted underwear	2.7	3	1,417	1115
Malleable-iron castings	9	11	4,107	1005
Writing paper	5.4	4	2,211	1000
Millwork—sash and doors	0.32	7	1,238	584
Yarn and thread	1	4	2,586	548

* Value of product furnished directly by individual companies and therefore comparable with man-hours worked.

† Where the number of companies is not given, the data are for either one or two establishments.

TABLE 3 WAGES, COST OF MATERIALS, VALUE OF PRODUCT, ETC., PER 1000 FACTORY MAN-HOURS FOR 12 INDUSTRIES

Industries	Ratio of compiled to census production, per cent	Number of companies	Number of employees	Wages per 1000 man-hours	Cost of materials per 1000 man-hours	Prime cost per 1000 man-hours	Value added by manufacture per 1000 man-hours	Overhead, selling expense, and profit per 1000 man-hours	Value of product per 1000 man-hours
Automobiles	83.0	12	151,447	$683	$4,240	$4,923	$2,190	$1,487	$6,419
Manufactured ice	6.2	6	1,061	796	1,010	1,806	3,220	2,334	4,240
Explosives	54.0	16	3,456	437	2,160	2,537	1,800	1,413	3,950
Paper and pulp	23.6	50	28,832	465	1,760	2,225	1,065	600	2,825
Portland cement	88	120	35,000	483	1,025	1,518	1,675	1,183	2,700
Carpets and rugs	8.5	4	2,334	605	1,460	2,065	1,188	575	2,640
Lumber	5.7	34	14,103	702	890	1,592	1,300	598	2,190
Firebrick	12	3	962	600	580	1,180		550	1,730
Rayon	68		3,500	440	350	790	1,330	890	1,680
Cast-iron pipe	6.2		1,783	372	655	1,037	695	313	1,350
Cotton fabrics	3.3	13	11,850	273	831	1,104	493	216	1,320
Leather shoes	2.1	6	6,534	272	605	877	556	243	1,120

complete paper presents data on this point for 53 product groups. The indications are in favor of the small plant when measured by the number of workers employed. This high production per hour, which must be accompanied by low manufacturing cost, may be a reason for the persistence of the small plant in spite of consolidations and mergers. A survey made by the Chamber of Commerce of the United States for the year 1927 shows that of 1701 newly located plants, 1537, or 90 per cent, employed fewer than 100 men.

An analysis of the data of this table shows that—

The smallest company has a higher rate of production than the largest company in 35 industries.

The smallest company has a lower rate of production than the largest company in 18 industries.

The smallest company has the highest rate of production in 16 industries and a high rate in 5 industries.

The smallest company has the lowest rate of production in 6 industries and a low rate in 16 industries.

The largest company has the highest rate of production in 3 industries and a high rate in 8 industries.

The largest company has the lowest rate of production in 18 industries and a low rate in 10 industries.

The smallest company has the highest rate of production and the largest company has the lowest rate in 8 industries.

The principal implications of the comparisons presented, wherein certain plants and certain industries are shown to have high values for production, value added by manufacture, selling value of product, wages paid, and net profit earned, all on the basis of one thousand factory man-hours worked, and certain other plants and certain other industries have low values for all these factors, are two:

That American industry may continue to progress,

1 Those plants having low operating factors, as shown by the man-hour basis, must be upgraded until their records are substantially equal to the average of their product group.

2 Those industries that have the lowest factors must be upgraded until they substantially equal in performance other industries that are making a satisfactory manufacturing profit.

The most potent attacks that can be brought to bear upon this problem of upgrading are in the reduction of waste, lowering of cost, and improvement of processes, equipment, and methods. In these activities the members of The American Society of Mechanical Engineers must play an important part during the immediate future. Millions of dollars must be spent in industrial research, and billions invested in new machinery and equipment. The economic expenditure of these sums will, in a large measure, become the responsibility of engineers.

The Development of the Airplane Engine in the United States

By CHARLES L. LAWRANCE,[1] PATERSON, N. J.

This paper confines itself to the history of the development of various engines, rather than to their details of design. Pioneers in flight had to develop their own engines. The Wrights chose the simplest solution of the engine problem, Curtiss a development from his motorcycle engine, and Manly the most individual and modern.

The Curtiss engine development led directly to the OX model, in production before the war, and largely used for training. The large engines were all superseded by the Liberty engine. This engine development was remarkably rapid. The first engine was on test 35 days after first setting pencil to paper, and the first 12-cylinder engine passed a 50-hour test under three months from the time the project was started. Meanwhile the Wright Company was producing Hispano-Suiza engines, and Dusenberg, King, Curtiss, and Lawrance were producing experimental engines. After the war the Curtiss K-12 engine was developed into the D-12 pursuit engine.

The Wright Company, successor to Wright-Martin, after the war developed the Hispano model E until it passed a 300-hour non-stop endurance test. Wright also developed the T-3 torpedoplane engine. Packard meanwhile developed a 500- and an 800-hp. water-cooled type. Wright bought out the Lawrance Company and started manufacture of the Lawrance J-1 air-cooled engine. The Pratt & Whitney Aircraft Company was formed and produced the Wasp engine. Wright meanwhile had redesigned the Lawrance engine, and brought out the J-5 or Whirlwind type.

IN DISCUSSING the development of the aircraft engine in the United States, I shall not deal with the detail dimensional and power characteristics of the various types considered, except where it is of special interest to do so. All this information is already published and available, and I shall confine my remarks to a general review of the work of the various engineers who have helped to build up the American aircraft industry to its present condition. I shall deal more particularly with the earlier efforts of the pioneers in aircraft-engine design and manufacture, and shall pass rather lightly over the more recent developments, as these are too well known for comment. During the past year a number of new engines have been developed, but these are so recent as not to have had time to influence the trend of aircraft construction, and therefore I shall not mention them.

Unfortunately during the 25 years which have passed since the first airplane flight many able engineers have spent both time and money in aircraft-engine work which, for one reason or another, often beyond their control, has never materialized as a manufactured article, and if I pass lightly over these efforts because of the necessarily limited scope of my paper, I do so with due reverence for the time and energy which they have expended and which all has contributed in greater or less degree to the present excellence of the American aircraft engine.

The Early Period

The first successful flight ever made and the early development of aircraft in the United States are closely connected with the development of the aircraft engine. Without the engine, all of these early flights would have been impossible.

As no engines suitable for flight were available, all three of the pioneers of aircraft development in the United States had to design and build their own engines, and these three engines, although in some ways rather crude when viewed in the light of the present day, show great ability when we take into consideration the quality and weight of the motor-car engine of that time.

Of the three early experimenters, the Wrights, Curtiss, and Langley, the Wrights chose the simplest solution of the aviation engine, contenting themselves with a light adaptation of the standard four-cylinder automobile engine of their time. Their chief interests were: first, the research into aerodynamics, which was necessary before they could hope to build a successful airplane; then the practical consideration of learning how to fly; the development of the best system of control; and only incidentally and as a part of the problems, the obtaining of a power plant sufficiently light and reliable to get them off the earth and demonstrate the correctness of their aerodynamic theories. This can be further accounted for by the fact that the Wright Brothers had recognized the tremendous importance of using propellers of sufficient diameter and proper rotational speed for their, as we see it, slow-moving airplane, and, knowing that efficient propeller conditions were essential, they preferred to work out a drive, which had the features of a reduction gear, and even went to the complication of driving two propellers in opposite directions rather than bother with a super-refined engine which would have been necessary in order to produce through a single direct-drive propeller the thrust necessary to maintain their airplane in the air. Such an engine, quite possible in the light of our present experience, would have taken years of research and large money investments, and quite conceivably might not have been perfected in time to insure to the Wright Brothers the fame and honor to which their wonderful aerodynamical research entitled them.

Although the Wright four-cylinder engine used in their first flight in 1903, with a bore and stroke of 4 in., followed the average motor-car-engine practice, it differed from most existing engines in some respects. The cylinders were placed in a horizontal position with the automatic inlet located over the exhaust valve, the stems of both being vertical, and the exhaust valves driven by rocker arms operated by a chain-driven camshaft The fuel was fed by gravity to a tube leading through the water jacket, where the fuel was vaporized, then into the inlet manifold, where it was mixed with the incoming air. Ignition was produced by a make-and-break spark, actuated from a separate camshaft. This engine as first used produced 12 hp. at 1090 r.p.m. for a weight of 179 lb., including an 18-lb. magneto. The crude system of carburetion could not be correct except at one speed, but this was of no importance as the engine was intended to be run at full power all the time. The automatic inlet valves gave good results at the slow speeds at which the engine was run, for, with valve springs of proper tension, very good inlet timing was possible.

This engine was afterward improved by the addition of a fuel pump, better cooling, better machining of the cylinders and pistons, and minor modifications, and in the flight of 1906 would hold 25 hp. continuously at 1300 r.p.m., but we can judge of the efficiency of the propeller system of this large airplane and rather

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heavy engine when we realize that the first flights were made with a modest twelve horsepower.

In 1906 a new engine of 4.375 in. bore and 4 in. stroke was developed, which would deliver 39 hp. at 1600 r.p.m. for a weight of 180 lb., which was the engine used by the Wrights in their first public flights in France and at Washington. The cylinders were individual, and stood vertically on an aluminum crankcase, and a fuel pump discharged the gasoline through metering orifices

CHARLES MATTHEWS MANLY (1874–1927)

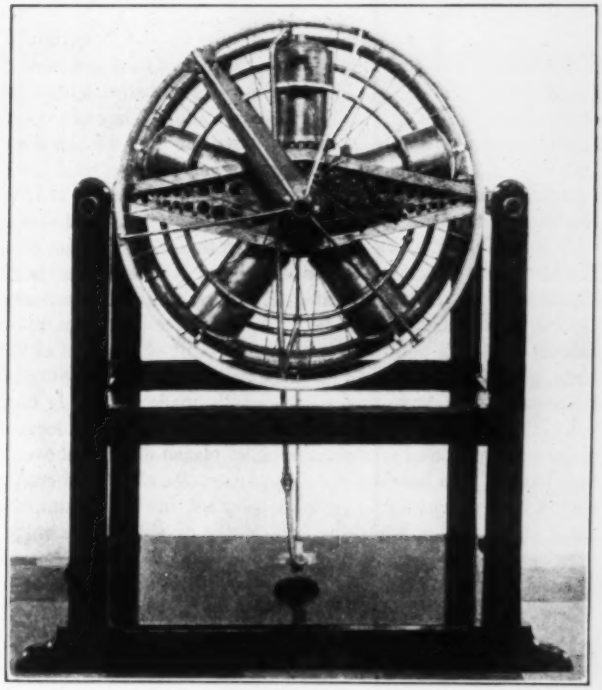
into the inlet port of each cylinder. Force-feed lubrication was used, a water pump was provided, and a high-tension magneto supplied the ignition.

Later a six-cylinder model was developed, with 4.5 in. stroke, mechanically operated inlet valves, and two carburetors, which developed 75 hp. at 1550 r.p.m. for a weight of 300 lb., or 4 lb. per hp.

However, the Wrights did not pretend to be engine builders, and an engine to them was merely a power plant capable of flying an airplane. They were students of aerodynamics, and we are assembled here in Washington at this time to pay tribute to their supreme genius.

In 1901 Glenn H. Curtiss, a young man of 23, residing at Hammondsport, New York, formed a company known as the G. H. Curtiss Manufacturing Company for the purpose of manufacturing motorcycle engines. The first models were crude affairs, but in a day when the only criterion of excellence of any motor vehicle was its ability to run, Glenn Curtiss' motors obtained a good reputation, and he was able to obtain capital to perfect their design. Always interested in the problem of speed, his tendency was to develop engines of light weight and high power, suitable for motorcycle racing, with the result that his engines were in great demand among the racing fraternity; and many races were run with Curtiss motors, culminating in a world's record which stood for ten years, and finally, in 1907, in an unofficial motorcycle record at Ormond Beach of a mile at the astonishing speed of 137 m.p.h.

Thomas Scott Baldwin was building a dirigible balloon in California in 1903, and searching for a suitable power plant he came across Glenn Curtiss' motorcycle, and ordered from Curtiss his first dirigible engine. This proved a great success, and through a succession of steps the motor was finally developed for the first United States Army dirigible, which in its acceptance test, in the summer of 1908, had to pass the then rigid specification of a two-hour continuous flight under the power of the engine. In order to deliver the necessary power, Curtiss developed a four-cylinder water-cooled engine. As an ardent advocate of air cooling, I cannot help deplore the fact that this great pioneer of aircraft engines at this time gave up the air-cooled engine. However, when we consider the low speed of Captain Baldwin's dirigible, it is obvious that air cooling might have been a doubtful expedient, and it only seems too bad that he never returned to it in his aircraft engines. Already this four-cylinder engine showed all the earmarks of the characteristic Curtiss design as known to all of us in the OX type, which I shall describe later.



FIVE-CYLINDER RADIAL ENGINE BUILT BY CHARLES M. MANLY IN 1902 FOR PROFESSOR LANGLEY'S "AERODROME"

In 1907 Dr. Alexander Graham Bell, J. A. D. McCurdy, F. W. Baldwin, Lieutenant Thomas Selfridge, and Glenn Curtiss formed the Aerial Experiment Association at Hammondsport, New York, and on March 12, 1908, the Curtiss engine made its first flight in an airplane. From then on development proceeded rapidly, and in the spring of 1909 Curtiss had developed an eight-cylinder engine of 50 hp., and was selected by the Aero Club of America to represent the United States in the Gordon Bennett race. Racing against the best that Europe could produce, he won by six seconds, establishing a world's record, around a closed course, of 46.50 m.p.h. It is interesting to note that the world's speed record of 1909 was less than the stalling speed of most airplanes of today.

During the progress of the Wright engine development Pro-

fessor Langley, who had been carrying on a most interesting study of the possibility of human flight, was building his man-carrying airplane, and had commissioned Charles Matthews Manly to construct an engine for him. I wish particularly to call your attention to this engine, for if the Wright Brothers were geniuses in the science of aerodynamics, as well as in the engineering judgment and good sense which characterized the conduct of their successive experiments, and if Glenn Curtiss was the practical type of engine designer most likely to succeed, Charles Matthews Manly was certainly the outstanding genius of early power-plant design. When we consider that the most popular type of airplane engine of today is almost identical in its general detail and arrangement with the one evolved by Charles Manly in 1902, we are lost in admiration for a man who, with no data at his disposal, no examples of similar art on which to roughly base his design, and no workmen capable of making the more difficult parts of his engine, nevertheless, through the processes of a logical mind, the intelligent application of the science of mathematics, and the use of his surprising mechanical skill, succeeded in constructing an engine developing 52.4 hp. for a weight of 125 lb., or a weight of 2.4 lb. per hp., which stood up under severe tests, once even going through a full power, non-stop run of ten hours.

This remarkable engine, which is now in the Smithsonian Institution, is a five-cylinder, four-cycle motor, having a bore of 5 in. and a stroke of $5^1/_2$ in. The cylinders are of steel, spun from a flat plate into a barrel having one closed end. They are $^1/_{16}$ in. thick, and into them is shrunk a cast-iron liner of the same thickness—a form of construction which must have caused many a pitying smile when he attempted to get some machine shop in Washington to make them for him. In fact, he was told that it could not be done, and so he had to turn to and show them how. The same was the case with the forged and machined steel ports which held the inlet and exhaust valves, and the sheet-steel jackets, all of which had to be brazed in place on the barrel, a difficult and even painful process, on account of the heat of the parts, which, after repeated failures that would have discouraged the average man, were finally successfully made by Manly himself. The five cylinders, each having an exhaust valve located in the valve port and an automatic inlet placed directly above it, were located on a barrel-shaped crankcase, like the radial crankcase of the present day, but made of steel, not aluminum, the latter at that time not being sufficiently reliable. The valves were operated by a two-lobe cam, running at half engine speed, and the pistons of cast iron were of a degree of refinement in lightness and design quite unknown in those days in the automobile world, and for a number of years to come.

The connecting-rod assembly consisted of a master rod and big-end bearing, and four link rods, running with the slipper-type bronze shoes on the outside of the master-rod big end, and held in place by steel clamping rings threaded into the big end. These rings also served to hold the two halves of the master-rod big end together. This system of construction, I believe, had already been employed in a somewhat different form in three-cylinder compressed-air engines used for operating torpedoes and in certain air compressors, but the use of this system of big-end assembly with five cylinders in a gasoline engine was, I believe, tried here for the first time. The width of each shoe, measured in degrees from the center of the crankpin, was very small, being around 60 deg., or about the minimum that can be successfully employed.

Everything had to be specially made, the ignition system, the carburetor, and even the spark plugs. This engine may indeed be characterized as the first "modern" aircraft engine in the world, and the fact that it was produced years ahead of any other modern engine, and by an American engineer, should be a matter of pride to all who are interested in the advancement of American aeronautics and the mechanical genius of the American people.

The Prewar Period

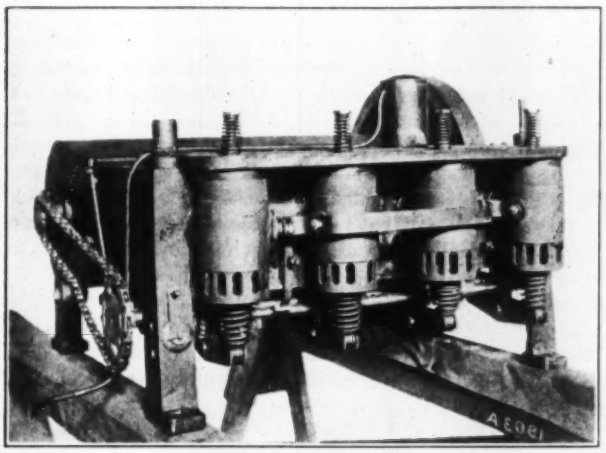
During the period prior to our entry into the Great War, and following upon the period of experiment carried on by the Wrights, Curtiss, and Langley, the greatest activity in aeronautical-engine development and production was carried on by the Curtiss Company. Through a series of developments, as outlined above, the Curtiss OX engine was finally evolved, and was the first American aircraft engine to be put into real production. No model of aircraft engine in any country has been in use for so many years as the Curtiss OX engine and its successive models. The last type of this model, the OX-5, of which the United States Government had constructed more than 9000 during the war, are still, 10 years later, in constant use, and the supply of these engines is only now giving out. I have no doubt that for a number of years to come we shall see engines of this type still in use in small sport-type airplanes.

As is the case with all engines produced in very large quantities over a period of time, the causes of failure are eliminated and a knowledge of the art of servicing and caring for them becomes so universal among the flying fraternity as to guarantee the greatest degree of reliability. This eight-cylinder 90-deg. engine of 4 in. bore and 5 in. stroke is rated at 90 hp., although with modification of the valve gear much higher power is possible, as has frequently been demonstrated at race meets. The shaft has five bearings and the connecting rods are mounted side by side. The cylinders of cast iron have monel-metal jackets, and the valves, located in the head, are operated by an unusual and ingenious system. The operating rods are concentric, an inner push rod operating the exhaust through large rockers, and the outer push-rod tube, actuated by a powerful spring and an aluminum rocker arm, pulls the inlet valve open at the proper time.

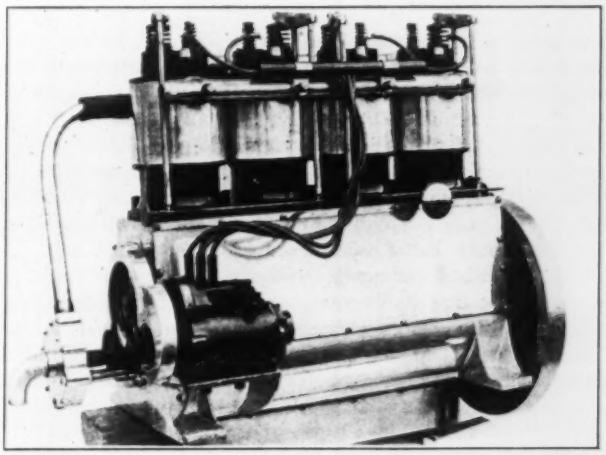
The Curtiss OX engine made possible the flight of most airplanes built in this country prior to the war, especially such ships as the JN type, a number of which are still in use, the N-9, only recently abandoned at Pensacola as the Navy training plane, and the F Boat, which has only disappeared from view in the last few years. The effect of the OX engine on American aeronautics has been incalculable. In the early days it provided an available power plant at a reasonable price. During the war it permitted the training of 10,000 American aviators. Since that time, sold from the Government stock at ridiculously low prices, it has been the standard power plant of low-priced planes throughout the United States. This engine and two others, the Liberty and the Wright Whirlwind, have in my opinion made American commercial aviation what it is today.

Another Curtiss-engine development, started about 1912–1913, was the model V, with a bore of 5 in. and a stroke of 7 in., which was built in both the 8- and 12-cylinder models, and culminated in the V-2 and V-3 eight-cylinder engines. A considerable number of these engines were used by our Army and Navy prior to our entry into the war, but, like many other promising designs, were eliminated by the more powerful Liberty motor. The V-3 was a very modern design, worked out in part by Charles Manly, referred to earlier in this paper, who was at that time an engineer of the Curtiss Company, and a project for flying the Atlantic in a large Curtiss boat, the *America*, contemplated the use of these engines.

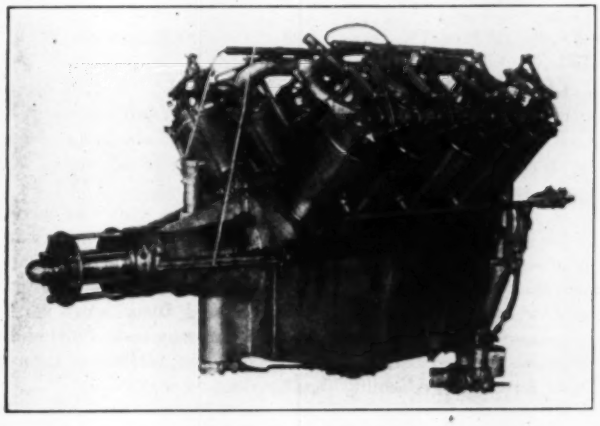
The entry of the United States into the war stopped the development of a number of promising aircraft engines, such as the Sturtevant, the Martin, the Christoffersen, the Wisconsin, the Packard, and the Hall-Scott.



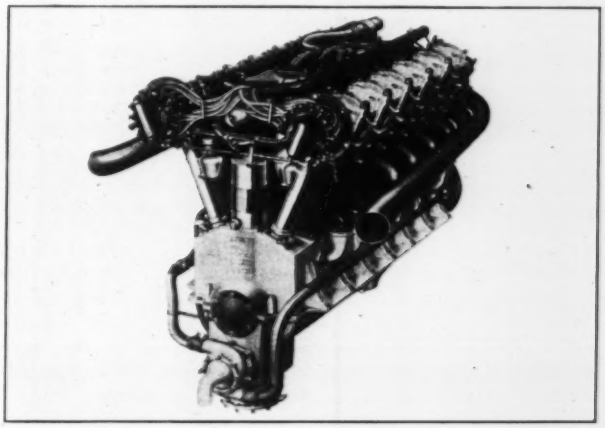
1903 WRIGHT MOTOR



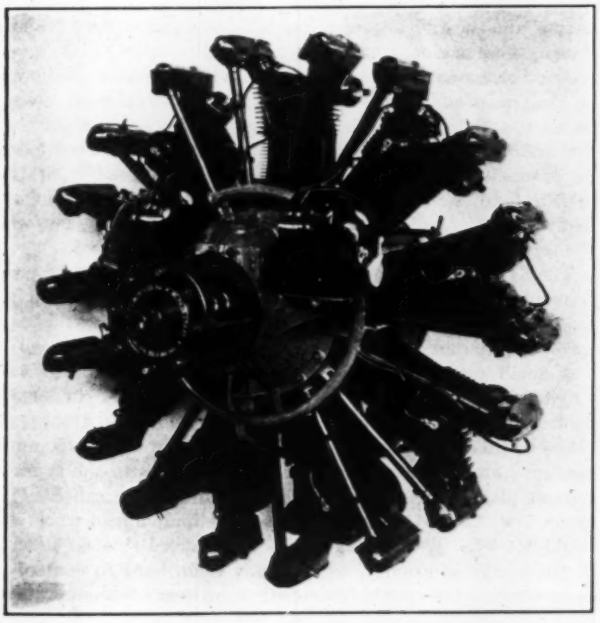
1910 WRIGHT MOTOR



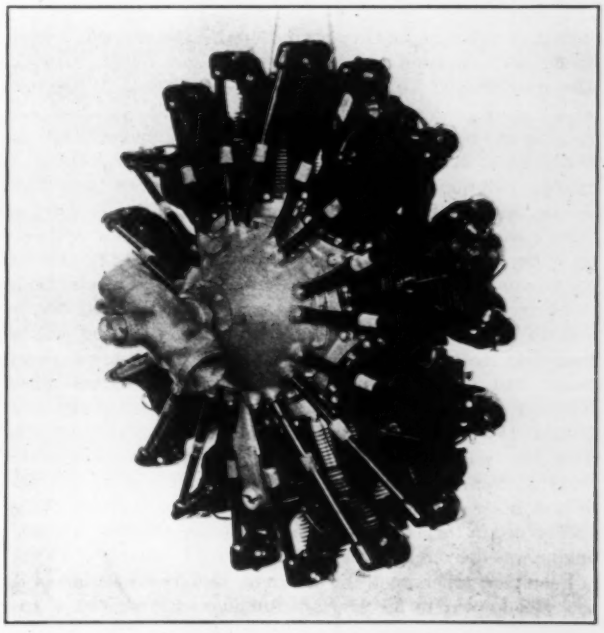
CURTISS OX-5 ENGINE



LIBERTY 12 ENGINE



WRIGHT WHIRLWIND J-5



PRATT & WHITNEY WASP ENGINE

The War Period

One of the earliest acts of the War Department upon the outbreak of hostilities was the formation of an Aircraft Production Board, including Howard E. Coffin, Edward S. Deeds, S. A. Waldon, Robert L. Montgomery, and General Squier, then Chief Signal Officer of the Army Signal Corps. This Board immediately sent a commission abroad to investigate airplane and engine designs, and the report of this Commission, added to the information supplied by the French and British Military Missions, indicated that it would be advisable for the Aircraft Production Board to commence the design and construction of an entirely new American engine, making use of the best detail design of other engines built both in this country and Europe, but of adequate power and adapted, from a manufacturing standpoint, to mass production in the United States. Certain European engines existed which would have been reasonably satisfactory from the standpoint of power and weight, but they did not seem particularly suitable for American manufacturing methods. Accordingly, acting under the instructions of the Aircraft Production Board, on May 29, 1917, Messrs. J. G. Vincent and E. J. Hall, assisted by several others, started the preliminary layout of an eight-cylinder engine of about 275 hp., which could be built also as a six- or twelve-cylinder model. Working continuously until 3:00 p.m. the next day, they made a rough layout, which was submitted to the Aircraft Production Board. More complete designs were then requested, and with the assistance of layout men who had been obtained from the Packard factory, and by working almost continuously night and day, complete and accurate layouts of the various sections were completed by the afternoon of June 4, or one week after the beginning of the project. These plans, which were then submitted with further specifications, were accepted, and Messrs. Vincent and Hall were requested to construct at once five eight-cylinder and five twelve-cylinder engines, with a maximum of only seven weeks for the completion of the first engine. These engines were to be known as the U. S. Standardized Aircraft Engines. The name "Liberty," by which this engine was referred to a little later in one of the Aircraft Production Board meetings, appealed so much to the imagination that it was finally officially adopted.

Such surprising speed in working out the design of a new engine would not have been possible had it not been for the fact that Messrs. Hall and Vincent had both been intimately connected with the design of similar engines. Mr. Hall had just completed the construction of a 12-cylinder engine of about 300 hp., and Mr. Vincent of the Packard Company had built a series of 12-cylinder aviation engines, of smaller power to be sure, but of very similar design. Using the drafting facilities of the Packard and other companies, 89 per cent of the detail drawings were finished by June 11, and the crankcase drawings by June 13. Through the concentrated efforts of the Packard, Cadillac, Lincoln, Dodge, and Pierce-Arrow plants, the parts were made at incredible speed, and on July 3, 1917, the first eight-cylinder engine was delivered to the Bureau of Standards for test, thirty-five days after pencil had first been put to paper. Other engines quickly followed and the first 12-cylinder Liberty finished its official 50-hour test on August 25, in an elapsed time of only 55 hours. This test was completed only 89 days (or just under three months) from the inception of the idea. Three months later, or just under six months from the time Messrs. Hall and Vincent had turned in their original recommendation, the first production engine was delivered to the Government.

I shall not touch upon the design of the Liberty engine as it is too well known to all who are familiar with aircraft engines. The excellence of this engine is well known. Superseded at present in the Army and Navy because of the demand for more powerful power plants, it is nevertheless still in use in certain air-mail operations. In one air-mail company it has been found that, with certain minor modifications, and run under not too severe conditions, this engine is good for about two hundred and fifty hours between overhauls. Knowing as I do the difficulty in bringing out a new engine design, the delays due to patterns, casting troubles, the experimental testing, and the manufacturing difficulties, all of which must be overcome before the model can be released, I cannot but feel that the achievement of Messrs. Vincent and Hall is one of the most outstanding feats in the history of aircraft-engine development.

During the progress of the war two other large aircraft-engine manufacturing operations were being carried on, one of which I have referred to above, namely, the production of Curtiss OX-5 engines. The other was the manufacture of Hispano-Suiza engines by the Wright-Martin Aircraft Corporation in their plants at New Brunswick, N. J., and at Long Island City, N. Y. The manufacture of the Hispano-Suiza Model A in the Wright-Martin plant was originally undertaken before this country went into the war, to supply engines to the French Government, but later contracts were awarded by the United States, both for the modified Model A, known as the Model E, and for the 300-hp. Model H. During the war 5816 engines of this design were produced. It was found very difficult to produce the French design of this engine under American manufacturing conditions, so under the direction of Henry M. Crane, at that time chief engineer of the Wright-Martin Company, successive modifications of this design were made, until the model was abandoned in 1923 in favor of the Lawrance air-cooled engine. This work was carried on by Mr. Crane and his assistant, George J. Mead, afterward chief engineer of the Wright Aeronautical Corporation, and now chief engineer of the Pratt & Whitney Aircraft Co., to a point where the small Hispano-Suiza model, then known as the E-4, succeeded in passing a full-power non-stop test of 300 hours in the Navy Yard Laboratory in Washington, setting, so far as I know, a record of reliability for any aviation engine.

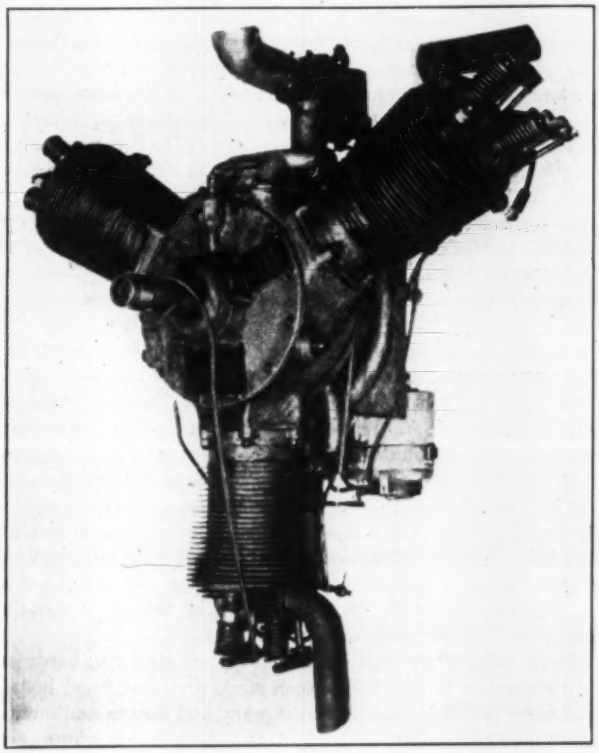
Another wartime development was the Dusenberg engine, with models of 125 hp., 300 hp., and 800 hp., which were built under experimental contracts with the United States Government. On account of the large production of other types, like the Liberty engine, and the difficulty of perfecting a new and rather advanced design, these engines were never produced in quantity.

Another experimental engine was the King-Bugatti, which was an American adaptation of the Bugatti two-crankshaft design, under the direction of Charles King, and under contract with the Aircraft Production Board. This engine was just commencing production in the plant of the Dusenberg Motors Corporation in Elizabeth, N. J., when the armistice was signed, and forty had been delivered and accepted by the Government, but with the termination of hostilities the contract was cancelled.

The Hall-Scott Company of Berkeley, California, had continued producing their 4-cylinder Model A-7, a 100-hp. engine, under a contract with the Navy Department, which was using it for installation in Navy training seaplanes.

A small company which I had started, the Lawrance Aero Engine Corporation, had developed a 28-hp., two-cylinder air-cooled engine, for use in special airplanes designed to teach pilots to take off without doing a ground loop, as was a common tendency among those who were not familiar with the types of pursuit plane of that day. These machines were called "Penguins," or "Grass Cutters," because they had clipped wings and could not fly. The landing wheels were placed very far in front of the center of gravity, which made them hard to control on the ground. They could be made to jump over a fence if properly handled. My company sold the design of this engine to the Signal Corps, who gave a contract to the Excelsior Motor Manu-

facturing and Supply Company, of Chicago, for 450 of these engines. The Lawrance Company was also working under contract with the Navy Department on a small 60-hp. air-cooled 3-cylinder engine for use in aircraft to be carried on submarines. The engine was perfected about the time of the armistice and was known as the Model L. A number of them were afterwards bought by the Army and used in Sperry "Messenger" planes, and a few were used by the Navy to be carried on submarines. These small engines were of no particular importance in themselves, but are of interest as immediate predecessors of the "Whirlwind" engine.



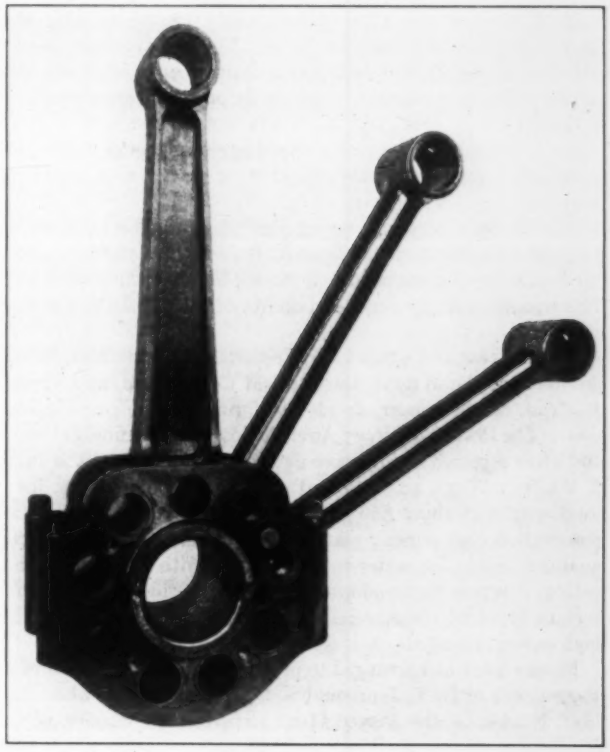
ONE OF THE STEPS IN THE DEVELOPMENT OF THE RADIAL AIR-COOLED ENGINE, THE LAWRANCE 3-CYLINDER L-4 TYPE AERONAUTICAL ENGINE

One of the most important engine developments carried on during the latter part of the war was an engine brought out without Government encouragement by the Curtiss Company, for use in pursuit planes, and known as the K-12. This was a very advanced 12-cylinder engine designed by Charles Kirkham, and was the predecessor of the well known D-12, which has had such a success in pursuit aviation since the war. It had a bore of 4.5 in. and a 6-in. stroke, with a rated horsepower of 400 at 2250 r.p.m. It was equipped with a reduction gear of a ratio of 1.66 to 1, and had a very small frontal area and small overall dimensions. It had four valves to a cylinder, with an ingenious operating mechanism, and a weight of only 1.70 lb. per b.hp. In my opinion it was a milestone in the development of water-cooled aviation engines.

THE POST-WAR PERIOD

Following the armistice, the development of the K-12 engine was carried on through the C-12 and C-6, a six-cylinder-in-line variation, to the D-12 Curtiss engine, which has been one of the most successful pursuit engines ever built. In considerable part, due to the genius of Arthur Nutt, chief engineer in charge of engine development of the Curtiss Company, this type of engine, so ably started by Charles Kirkham, has become one of the most reliable and rugged power plants in existence, and maintained its supremacy in the pursuit-engine field until the last two years when the Pratt & Whitney "Wasp," which I shall speak of later, began to invade its territory.

At the close of the war the Packard Company, desirous of continuing the leadership in engine design that it had established during the war by its part in the Liberty-engine development, brought out some new models suitable for commercial use. These were 8- and 12-cylinder engines, of 180 and 280 hp., respectively, and were improvements on the Liberty-engine design. However, the immense war stocks of Liberty and Hispano-Suiza engines precluded the sale of any quantities of these new models to the Government, and commercial aviation was not yet developed. Packard then turned to the design of a much bigger model, the 560-hp. 12-cylinder engine, which was used in a racer



MASTER CONNECTING ROD OF A 9-CYLINDER RADIAL ENGINE, AN ESSENTIAL ELEMENT OF THIS TYPE OF ENGINE
(Two of the 8 link rods are shown on the right.)

designed by Arthur Verville, which won the Pulitzer Trophy in 1920. A number of these were purchased by the War Department, and used in various racers and bombing airplanes, but the type was not perpetuated.

Under the direction of L. M. Woolson, chief aircraft-engine engineer of the Packard Company, two very interesting designs were brought out about 1924, a pursuit engine of somewhat greater power than the Curtiss D-12 and a large bombing and torpedoplane engine. These were purchased in a considerable quantity by the Army and Navy, and many of them are in service today.

After the armistice the affairs of the Wright-Martin Aircraft Corporation were liquidated and its business was taken over by a newly formed company, the Wright Aeronautical Corporation. As I stated above, the Model E Hispano-Suiza was perfected, and

the Model H 300-hp. Hispano-Suiza further developed. An order was received for 300 of these engines for Army pursuit work, but at the conclusion of the contract they were superseded by the Curtiss D-12.

The demand for a more powerful engine than the Liberty, for use in heavy torpedoplanes, led the Wright Company to bring out new engines of original design, under the direction of George J. Mead, called the Wright T-2 and T-3. These engines, of simple and robust design, proved very satisfactory until the increasing demand of the Navy for heavier and larger torpedoplanes led to their abandonment in favor of the 800-hp. Packard. They are still built as marine engines, for express cruiser use, where they give excellent satisfaction.

Meanwhile the Lawrance Aero Engine Corporation had developed, at the request of the Navy, a 9-cylinder radial air-cooled engine known as the Model J. The Bureau of Aeronautics of the Navy Department had realized that many of the troubles of aircraft power plants were due to water cooling, and resolved to enourage a 200-hp. air-cooled engine to take the place of the Model E Hispano-Suiza. This took courage, as the latter was probably the most reliable engine then in existence, and no new air-cooled engine could hope at once to compete with it in that respect. However, the orders were placed, and, in spite of some difficulties, the new engine proved its worth to such an extent that very important orders were placed with my company.

The Wright Company, seeing that their water-cooled-engine business was diminishing, decided, rather than start an independent air-cooled-engine development, to buy out my company. This was accordingly done, and on May 15, 1923, the merger was completed.

About a year and a half later, Frederick B. Rentschler, former president of the Wright Aeronautical Corporation, and George J. Mead, chief engineer, decided to form a new engine corporation. The Pratt & Whitney Aircraft Co. was accordingly started, and after a period of intensive development produced the Pratt & Whitney Wasp, an air-cooled engine, rated at 425 hp. for a total weight of about 650 lb. Used originally by the Navy for observation and pursuit planes where it has shown very good qualities beside the water-cooled engines, with which it is competing, it is now being adopted to a very considerable extent for certain types of commercial transport planes, especially where high power is desired.

Meanwhile I had arranged to procure for the Wright Company the services of E. T. Jones and S. D. Heron, both of whom had been located at the Power Plant Experimental Station of the United States Army at McCook Field, Dayton, Ohio, where they had been carrying on a series of experiments in the design of cylinder heads for air-cooled engines. These researches and experiments, covering a period of years, were very comprehensive in character and showed some very remarkable results. E. T. Jones became chief engineer of the Wright Company, and it was decided to redesign the former Lawrance 9-cylinder engine, then known as the Wright J-4 B, taking advantage of the experience of Jones and Heron in air-cooled-cylinder design. The new engine was known as the J-5, or "Whirlwind." Its power was no greater than before, but the specific fuel consumption was about as low as that of any water-cooled aviation motor ever built. It was thus remarkably suitable as a power plant for the extraordinary series of transatlantic and transpacific flights which characterized the year 1927, and which turned the minds of the whole world to the possibility of flying. With these epoch-making flights, the science and industry of aviation turned the corner from poverty to success, and the future of aviation in the United States became as assured as the future of the automobile industry.

Chromium: A Helper of Iron in Service to Man

CHROMIUM, known as a chemical element since discovery by Vauquelin about 1800, was but little used until after 1827. Then a young man named Tyson, who had had experience with a British metallurgical company, noticed while in the Farmers' Market of Baltimore, Maryland, a farmer who had propped his cider barrel with chunks of black mineral which Tyson recognized as chromite. Inquiry led him to the finding of this ore in northern Maryland and in Pennsylvania. With the financial assistance of his father he organized the chromite industry of the Maryland-Pennsylvania district. For nearly fifty years they dominated the world supply.

About 1869, the Chrome Steel Company, of Brooklyn, started producing ferro-chromium by carbon reduction in crucibles and making chrome steel therefrom. In 1877, Brustlein began large-scale manufacture of chromium steel in France by a similar method. Shortly thereafter another French works began to make ferro-chromium in the blast furnace. In 1892 Sir Robert Hadfield published his classical paper, which gave fresh impetus to research. About this time Osmond, Arnold, Le Chatelier, Roberts-Austen, and others were laying the foundations of the metallographic theory of steel, particularly of alloy steels.

Among the first conspicuous uses of chromium in steel was that for the Eads Mississippi River bridge at St. Louis, in 1874.

In 1896, at Spray, North Carolina, De Chalmot produced ferro-chromium in the electric furnace. In 1897, commercial production by this method was begun at Holcomb Rock, Virginia. Soon the reduction of chromium by fuel heat everywhere gave place to electric smelting, the high temperature of which enabled production of alloy richer in chromium, more uniform of content, and lower in cost. Carbon content of about 6 per cent was too high for some steels. Ferro-chromium lower and still lower in carbon was demanded until now much of this alloy contains less than 0.10 per cent of carbon.

Even below 1 per cent chromium confers strength, hardness, and resistance to abrasion. Such steels are most usual in ball and roller bearings, case-hardened gears, and mining and milling machinery subjected to hard duty. Nickel, vanadium, and molybdenum often participate in low-chromium steels special to the automobile—materials which successfully resist terrific strains imposed by a hard-driving public. High-speed tool steels which have made possible the fine automobile at low cost draw their fast-cutting durability from the indispensable association of chromium with tungsten.

Rustless irons resemble stainless steels in chromium content, but by reason of the intentionally low carbon are soft. Their formability permits use in nitric-acid plants, in seamless tubing for thermal "cracking" processes, and in steam-turbine blades. Chromium imparts to steel greater toughness: strength and hardness alone do not protect against breakage under the shocks to which modern high-speed machinery is subjected.

Chromium and ferro-chromium, its principal commercial form, are not commonly known to the public, although essential constituents of a vast number of metal products in daily use, e.g., heating wires in electric toasters, waffle irons, stainless-steel cutlery, chromium-plated kitchen and bathroom fixtures.

Retention of strength and resistance to oxidation at high temperature make chromium-nickel alloy useful also for other household and many industrial electric-heating devices. With sufficient chromium, certain alloys become very resistant to many sorts of chemical attack. The greatest economic service of such metals is in dairies, chemical plants, and apparatus which must resist corrosion and avoid contamination of products.—From the Engineering Foundation's publication, *Research Narratives*, vol. 8, no. 12, 1928.

Engineering Methods Applicable to Agriculture

Complexity of the Agricultural Problem—Comparative Agricultural Production Costs and Conclusions Which They Suggest—Need for a Thorough Engineering Analysis of Agricultural Industries—A Suggested Outline of Study and the Results to Be Expected Therefrom

By L. W. WALLACE,[1] WASHINGTON, D. C.

THE state of American agriculture has been a matter of serious consideration and concern for some years. It is universally recognized that there is a farm problem of importance and seriousness. Many attempts have been made to state the problem, complex as it is, and to prescribe a remedy. Limited studies of different phases of the problem have been made, but as valuable and thorough as these studies have been, there is a large body of thoughtful men who feel that a sufficiently comprehensive study has not been made and a feasible solution has not been stated. Many have argued that there should be a transformation of agriculture, but no one has made evident what they mean or how a transformation is to be accomplished.

Many are making the mistake of considering agriculture as a unit. It is not a unit. It is as diverse as industry in its concepts, objectives, and problems. Composite agriculture is made up of numerous large and important units, each with sharp lines of difference. The grower of cotton, of corn, wheat, and of fruit confronts economic and production problems quite different from those of the producer of beef, pork, and milk products. Furthermore the problems of the producer of cotton are not identical with those of the corn and wheat farmer, and in turn his conditions do not parallel those of the fruit producer, although he is located in the same relative territory. There are common factors to be sure, as there are factors common to all manufacturing plants, banks, and merchandising establishments. But it is the factors peculiar to each that give the greatest concern and require the greatest acumen to successfully control.

Geographical location carries its own peculiar and specific problems. The wheat grower of Illinois is influenced differently from the grower of the Dakotas, and both have problems unlike those of the producer of Oregon which are wholly due to geographical location and are all implied thereby. These clearly obvious facts have been overlooked.

The Agricultural Problem Not a Simple One

The agricultural problem in a very large measure has been discussed as if it were a composite mass in one warehouse. The proposed relief measures have apparently been based upon the supposition that if the warehouse were given an adequate treatment with some disinfectant, the contents thereof—the agriculture mass stored therein—would be relieved of all gnawing and debilitating germs, and after the treatment would be released as a mass in a state of vigorous health with a long life of growth ahead. The problem is not so simple. Even if agriculture were a unit, the same in content throughout the nation, the problem would not be easy of solution. We have abundant evidence of this fact. To realize it we need only to give a minute's thought to the production of coal. This process is perhaps as uniform as any large-scale endeavor we can think of, but the condition of the coal-mining industry has been and is now as distressing as any that can be instanced, notwithstanding the efforts of many able and thoughtful men.

It is the conviction of engineers that a thorough engineering analysis of the agricultural industries patterned somewhat on the lines of the study of "Waste in Industry" would inevitably point the way to a fundamental and an economic improvement throughout the realm of agriculture. . . . . .

The American Engineering Council in cooperation with the American Society of Agricultural Engineers and other groups, hopes to initiate and prosecute a study which will encompass the economic, social, financial, and engineering phases of agriculture. . . . . .

The analysis is designed to point the way to practical and measurable standards of agricultural management; to an understanding of the interrelation and interdependence of agriculture, commerce, and industry; to better agricultural financing and credits; to improved marketing facilities and results; to lower unit costs of production; to the elimination of avoidable waste in farm activities and products; to improved rural conditions through greater use of power and mechanical equipment; and to larger net returns and high standards of living for those engaged in the agricultural industry.

Another faulty phase of thinking regarding agriculture is that its condition and its problems are peculiar to the United States. This is not the case. The state of American agriculture is not unlike that in many parts of the world.

The World Economic Conference, held in Geneva in 1927, gave serious consideration to the state of agriculture throughout the world. The conference had before it authoritative documents relating to agriculture in many countries. In the light of these reports, the Conference said:

> Agriculture is at present hampered in the complete fulfilment of the economic role which has been assigned to it by a general depression varying in degree but affecting a large number of countries on which the world depends for its supply of foodstuffs and raw materials.
>
> The interdependence existing between nations is no less close between the main classes of occupations—agriculture, industry, and commerce—and it would be vain to hope that one class could enjoy lasting prosperity independently of the others.
>
> The diminution in the purchasing power of the agricultural population has reacted upon industrial production, and is consequently one of the causes of unemployment, which in its turn reduces the outlets for agricultural products. . . . . Technical means exist, however, for a considerable development of agricultural production. They must therefore be put into operation. Their general adoption would have the most beneficial consequences for the prosperity and economic peace of the world.

[1] Executive Secretary, American Engineering Council. Mem. A.S.M.E.

The Economic Conference came to this significant conclusion:

> Great as is the value of the documentation which has served as the basis for the discussion on agriculture, it must be acknowledged that there is not yet a sufficient foundation to permit a complete analysis of all the problems as to suggest a solution of them.

The Conference further said that the first measures for improving agriculture are the general adoption of better technical methods; more scientific organization; an extension of the international campaign against diseases of plants and animals by cooperation; and the organization of credit institutions.

The Conference recommended that in each country there be made—

> ...a general inquiry into the present situation; into the possibilities of developing agriculture; into the distribution of holdings and exploitation; into the relations between agricultural and industrial production; into the comparison between agricultural and industrial prices; into the condition of the workers; and into the facilities required for their access to land. In fact, into the economic, social, financial, and technical conditions of agriculture, the study of which will permit further progress to be made.

In short, the Economic Conference realized that there were not sufficient fundamental data available upon which to base a solution of the agricultural problem. In recognition of this fact it recommended that a thorough and exhaustive study be made in each country.

Some will contend that we have ample facts—that the farmers know what the trouble is, and hence can state the solution. It is granted that some things are known, but it is not admitted that a sufficient number of concrete analyses have been made to give a clear-cut conception of the conditions prevailing, and without such a conception little can be done to point the way to a wholesome and satisfactory solution. Let us review some of the facts and raise some queries suggested by them.

Perhaps one of the most significant facts is that for some years agriculture has gradually been getting away from the idea of planting, tilling, and harvesting crops which the family will consume and utilize. Many are finding themselves rather suddenly alienated from the self-sufficient family-enterprise idea of agriculture. It is now being regarded more as a commercial enterprise. Those who do not realize this change are confused. Those who do or do not realize it and cannot cope with it are doomed to failure. Those who realize the change and are competent to cope with it are succeeding. There is abundant evidence to support the foregoing statements. A few comparative statistics will throw considerable light on the situation.

Comparative Cost Figures

The cost of producing butter fat on 25 farms in the same community in Minnesota varied from 29 to 71 cents per pound, and the returns from the cows ranged from a loss of $36 to a profit of $67 per cow per year.

The milk-production contest of the Iowa Contest Association showed the following results: The feed cost for a group of cows producing 500 pounds of butter fat per year was 17 cents a pound, whereas for a 200-pound group it was 22 cents per pound. The labor return on the 500-pound group was 39 cents per hour, and on the 200-pound group, 6 cents an hour. The men who owned cows which produced from 100 to 125 pounds contributed 12 cents per hour for the privilege of owning, feeding, and caring for the cows.

The records from a number of farms interested in the ton-litter work show that the number of pigs raised per sow ranged from 3 to 12. The number of pounds of pork gained per bushel of corn fed ranged from 7 to 12. In 1914 the cost of the grain fed ranged from 5½ to over 14 cents per pound of pork gained.

The figures for 1922, 1923, and 1924 for Humboldt County, Iowa, show that the amount of corn fed per 100 pounds of pork produced varied from less than 5 to more than 13 bushels.

In 1926 reports from statistical poultry farms in Minnesota show that the cost of feed varied from $1 to $2.55 per hen per year. The returns from hens ranged from a loss of 30 cents to a net profit of $1.50 per hen per year.

Chicken flocks vary from 30 to more than 125 eggs per hen per year.

In 1927 in Western Nebraska it cost 32 cents to produce a bushel of wheat, whereas in Eastern Nebraska it cost 86 cents, or almost a threefold difference in favor of the section producing on a large scale and utilizing power and machinery.

The ten-acre corn-yield contests in Nebraska in 1924 show some illuminating results. Twenty-one contestants used 4 or more horse-hours per man-hour, while 51 contestants used less than 4 horse-hours per man-hour. The yield per acre was approximately the same for both groups. However, the 21 contestants who used more horsepower and machinery produced corn at an expenditure of 5.3 man-hours per acre, and the group which used less horsepower and machinery expended 7.6 man-hours per acre. The first group realized a net profit of $12.53 per acre, and the second group, $11.63. On the showing made the first group could handle 100 acres with the same number of man-hours as the second group required for 70 acres. This would mean that the first group would earn $1253 and the second $795, a difference of $458.

Striking differences are shown by comparing individual performances: A produced 76 bushels per acre with an expenditure of 11.2 man-hours per acre. B produced 76 bushels per acre with an expenditure of 3.3 man-hours per acre. A made a profit of $12.63 per acre, and B a profit of $18.63.

If A could handle 50 acres up to husking without hired help, then B by expending the same number of man-hours could cultivate 170 acres. Under these conditions, A would make a net profit of $631.50 and B, $3097.60. A would earn $1.48 per hour worked, and B, $5.89.

The corn produced in two counties in Iowa in 1923 ranged in cost of production from 15 to more than 75 cents per bushel. The farm which produced corn at 75 cents per bushel is as good as the one which produced it at 15 cents per bushel and could carry as large a loan.

The cost of pump irrigation in Nebraska varies from 31 cents to $6.98 per acre. Irrigation costs or the costs of distributing water range from 35 cents to $4.48 per acre. The total cost per acre varies from 89 cents to $9.53.

Of course, some of this variation is easily accounted for by difference of conditions. However, by placing all the plants on the same basis the cost varies from 10 cents to 92.7 cents per acre-foot of water for each foot of lift.

The 1925 records of the "More Cotton on Fewer Acres" Contest of the Dallas, Texas, *News* also show some interesting facts. The plots were 5 acres in extent. The average production of lint cotton per acre for the state was 133 pounds, and the average cost was 21.4 cents per pound. However, in the contest 27 farms produced an average of 1241 pounds per acre at a cost of 4.7 cents per pound. The performance of a group of 18 farms was 875.6 pounds of lint cotton per acre at 5.9 cents per pound. Thirty-two farms averaged 730.6 pounds per acre at a cost of 6.8 cents per pound. Each group showed a decreasing cost for an increasing yield.

The production performance on a 200- and a 400-acre farm in De Kalb County, Illinois, is striking. They plant corn check-rowed with a 4-row planter tractor drawn at the rate of 52 acres per day of 8½ hours. They operate two rotary hoes at the rate of 70 acres per day. They cultivate 50 acres of corn per day. They cut 35 acres of wheat with a 10-foot binder per day. They cut hay at the rate of 40 acres per day.

Such records as the foregoing raise many questions. The thoughtful man wants to know the "why" of such variations. He asks: Why is one farmer able to accomplish so much more than his neighbor? What are the factors contributing to such differences? Were all the farmers to show the results the best ones do, would there be a farm problem to vex the nation? Have some farmers found the way out, and if so, what is it?

Conclusions Suggested by Comparative Cost Data

Such statistics suggest some possible conclusions. Among them are:

Output per worker and not output per acre is the important thing

Increased yield and therefore increased income per worker comes through the use of more power and machinery

Competent organization and management beget satisfactory results

Management as broad in its conception and execution as the best in industry and commerce, realizes returns comparable with those of industry and commerce

Industrial methods and practices when intelligently adapted to agriculture are profitable devices.

Agriculture should industrialize its operations to the point where it can produce enough in one hour to exchange in the markets of the world for that which is produced in the same time. Agriculture cannot be content, as now, to exchange products requiring 2.18 hours to produce for manufactured commodities made in one hour.

Best Practices and Results, Not Averages, Should Be Emulated

The best practices and results, not averages, should be known and emulated. It is fallacious to compare performances with averages. No distinct accomplishment in any walk of life is realized by so doing. The 100-yard runner does not endeavor to beat the average but the best time of record.

But are such tentative or hypothetical conclusions justified? Do the data available support them? In so far as they go, yes, but they are entirely too meager. A sufficient body of such data has not been collected and adequately analyzed to justify a conclusive decision. The most that can be said about them is that they present a puzzling situation—one that demands a most searching analysis, without which neither sound nor fundamental conclusions can be drawn. Such a situation is not unknown to engineers. A comparative situation once existed in industry and still exists in some branches and in a large number of manufacturing plants. But beginning with the work of the first great engineers and continued to the present hour there have been applied to industry the processes of the engineer. These processes, which are simple and helpful when applied with judgment supported by experience, are analysis and synthesis.

Early in 1921 such processes were applied to American industry and resulted in the now well-known report "Waste in Industry." That study showed the great weaknesses in American industry and the avenues through which hundreds of millions of dollars of avoidable waste were occurring annually. It created a new phrase in the English language, a new movement in American life—"the elimination of waste."

It has been estimated that the annual savings in America due to this report are of the order of $600,000,000—all the result of applying engineering methods to industry.

A Thorough Engineering Analysis of the Agricultural Industries Needed

It is the conviction of engineers that a thorough engineering analysis of the agricultural industries patterned somewhat on the lines of the study of "Waste in Industry" would inevitably point the way to a fundamental and an economic improvement throughout the realm of agriculture. Consequently, some three years ago, the American Society of Agricultural Engineers and the American Engineering Council directed their attention jointly to the agricultural situation. They have come to the conclusion that a thorough and comprehensive engineering analysis of the agricultural industries is badly needed and would be exceedingly helpful.

The procedure recommended by the World Economic Conference for improving the state of agriculture is in all essentials similar to that long since applied to American industry.

The American Engineering Council, in cooperation with the American Society of Agricultural Engineers and other groups, hopes to initiate and prosecute a study which will encompass the economic, social, financial, and engineering phases of agriculture.

The objective of such a study will be to direct attention through methods of engineering analysis to the hindrances to agricultural development and well-being, and to suggest specific means of removing them. To be most helpful such a study must be definitely related to the objectives and ideals of the agricultural industry.

General Outline of Suggested Study

In this paper no attempt will be made to break up each topic into all of its elements, or to prescribe the methods of treatment in each case. Such detail is a matter to be included in a work sheet. It is recognized that many influencing factors other than those to be listed herein will have to be considered in some detail during the progress of the work. No factors of significance should escape the requisite amount of study and consideration.

In conducting the study, the best practice relating to each topic should be ascertained, and that practice established as the standard by which to gage the efficiencies of other practices. That is, no theoretical standards or systems of procedure should be promulgated. On the basis of good agricultural practice, authoritative experience records, and sound engineering thought, the best possible plan of procedure for each function of the agricultural industry should be recommended. The foregoing procedure should be followed for the entire agricultural industry and each major division thereof, as animal husbandry, cotton, corn, wheat, dairying, tobacco, fruits and vegetables, and allied activities. An analysis should also be made by geographical divisions, climatic, and soil conditions, and other governing factors.

Such topics as the following should be studied in the manner above indicated:

Organization. Types of organizations prevailing in the agricultural industry and its several subdivisions. Development of recommended type of organization best suited to each condition.

Management. Analytical study of the management principles and practices in vogue, and preparation of recommended principles and practices based upon the best experience of agriculture and industry.

Production. Make a thorough analysis of all production practices and methods, and point out defects and practicable means of correction. This should include a consideration of such items as the following:

a Types of equipment best adapted to the several conditions—their cost, value, and efficiency

b Power requirements—quantity and kind of power used, kind of power best adapted, and cost and efficiency

c Production per acre and per worker—by quantity and cost

d Labor conditions, management, and compensation

e The nature of soil with relation to efficient handling and economic production
f In general, all phases of planning and controlling production which affect net returns.

Elimination of Waste. The character and quantity of waste occurring in agricultural operations should be determined and means of avoidance suggested.

Utilization and New Uses. A thorough study should be made of the uses to which agricultural products are now put and their adaptation to new uses, including farm wastage.

Standardization and Simplification. A determination should be made of the degree to which the standardization and simplification of products, implements, and processes have obtained the benefits derived; and avenues of future effort should be outlined.

Cost Accounting. The World Economic Conference stated:

> The fundamental importance of agriculture demands an exact knowledge of its economic situation. Such knowledge can only be gained satisfactorily through a methodical analysis of farm accounts.....To achieve this.....an exact system of farm accounting should be formulated.....The system should make it possible to study the influence exerted on the net return by the factors of greatest importance: namely, wages, fertilizers, taxation, social charges, prices, indebtedness, etc.

A thorough canvass should be made of this subject and the essential elements of a simple cost-accounting system developed as a means of production control, as is the practice in industry. This consideration should include such items as the following:

a Cost of production—unit costs
b Management costs
c Overhead expenses
d Marketing costs
e Relation of land values to net returns
f Relation of agricultural and industrial costs and prices
g Labor, material, and equipment costs and relationships
h Budgetary control.

Effect of Seasonal Operations and Business Cycles. Seasonal influences have a very important bearing upon many phases of agricultural operation, and likewise the business cycle. These influences should be studied as thoroughly as possible.

Marketing and Sales. The agricultural industry is greatly handicapped because of no adequate and broad-gaged sales and marketing policies and agencies. A thorough study of this situation should be made. The study should include such items as:

a Cost of marketing
b Profit and price
c Sales organization for agriculture
d Market requirements and channels of trade
e New markets and uses
f The influence of transportation upon marketing.

Finance and Credits. The machinery of agricultural financing and credits requires complete revision. Therefore, particular attention should be given to:

a Capital investment and the practices and policies associated therewith
b Credit systems and policies
c Credits in relation to farm turnover
d Differentiation between financing and speculation
e Financing production on earnings as contrasted to pledging basic capital.

TIME REQUIRED FOR A COMPREHENSIVE STUDY

The program proposed is a comprehensive and all-embracing one. It should be so, because no such study has been made, and furthermore only by an inclusive survey can an intelligent perspective be obtained. Its execution will require a thorough search of all authoritative literature, consultation with experts in many lines of activity, and extensive and original field work. The fullest possible use should be made of available material so there may be a minimum amount of duplication. The study proposed may be considered in many particulars as an effort to correlate and codify reliable but unconnected and disassociated material that a broad but pointed perspective may obtain. It is contemplated it will require five years to execute the program with the scope and thoroughness required.

In making an engineering analysis of the agricultural industries, the technique should follow this general course: A general committee to organize and direct the work, the personnel of which should be so selected as to have on the committee men of high standing, experience, and ability, and particularly qualified to deal with the several phases of the problem. This committee should prescribe the general policies, determine upon the character and scope of the study, employ the necessary expert staff, and supervise the preparation of and certify to all reports that may be prepared. The staff should be so formed as to have thoroughly competent and reliable experts on each major subject treated.

RESULTS TO BE EXPECTED

The analysis proposed is designed to point the way to practical and measurable standards of agricultural management; to an understanding of the interrelation and interdependence of agriculture, commerce, and industry; to better agricultural financing and credits; to improved marketing facilities and results; to lower unit costs of production; to the elimination of avoidable waste in farm activities and products; to improved rural conditions through greater use of power and mechanical equipment; and to larger net returns and high standards of living for those engaged in the agricultural industry.

Contribution of Mechanical Power and Invention to American Agriculture

THE transition from animal power to mechanical power began with the introduction of the internal-combustion engine shortly before the close of the last century. It was not, however, until the last decade that such power was used extensively in agriculture. The tractor, the combine harvester-thresher, and the truck, all driven by internal-combustion engines, have now become thoroughly established farm machines. The rapidity with which they have been accepted is evidenced by the change that has taken place in such agricultural states as Kansas where the number of tractors increased from 5400 in 1918 to over 50,000 in 1928, and the number of combine harvester-threshers rose from fourteen in 1918 to a number estimated to be not less than 20,000 in 1928. This change is typical of that which has taken place in the principal agricultural regions of America. Thus, not only has more power been made available for agriculture, but there has been released for other uses fifteen to twenty million acres of crop land formerly required to feed the animals which have been replaced by mechanical power.

Seventy-five years ago, when most of the operations on the farm were performed by human labor or at most with the power unit consisting of two horses, and when the walking plow, the spike-tooth harrow, the scythe, and the cradle were the most efficient farming tools, it was possible for the average farm laborer to care for only about twelve acres of crop land. Now with modern farm equipment he tills thirty-four acres of land. This represents an increased efficiency of nearly 300 per cent.—L. E. Call in *Science*, January 18, 1929, p. 57.

European Hydraulics

Observations During a Year's Study as a John R. Freeman Scholar of The American Society of Mechanical Engineers

By BLAKE R. VAN LEER,[1] WASHINGTON, D. C.

AS A TOKEN of appreciation of his profession and especially the field of Hydraulic Engineering in which he has achieved fame, fortune, and happiness, Mr. John R. Freeman, Past-President of the A.S.M.E. and A.S.C.E., presented in 1924 to each of the following three societies, the A.S.M.E., the A.S.C.E., and the Boston Society of Civil Engineers, the sum of $25,000.

Much has already been done with the income from these funds, but the climax of their utility came in 1927, when Mr. Freeman, always sensitive to the public need, was greatly impressed by the terrible Mississippi River Flood. He and many eminent authorities in hydraulics have for several years advocated the establishment by the U. S. Government of a National Hydraulic Research Laboratory. Those who have seen the work of the European hydraulic-structures laboratories are convinced that many of our hydraulic problems could be solved by the use of similar methods. Hence, in order to focus public attention upon the correct manner in which to attack these problems, Mr. Freeman requested that the three engineering societies mentioned above select scholars to go to Europe to inspect and study the great hydraulic laboratories there. He also provided considerable additional funds for this purpose. In compliance with Mr. Freeman's suggestion the following John R. Freeman Scholars were selected: H. N. Eaton and B. R. Van Leer from the A.S.M.E.; L. G. Straub and M. P. O'Brien from the A.S.C.E.; and F. T. Mavis and K. C. Reynolds from the Boston Society of Civil Engineers. Each of these men reported monthly to his society, and upon the completion of his study abroad made a final complete report.

The plan followed by the author in accomplishing the purposes for which the Freeman Scholarships were awarded was, first, to visit the European technical universities, giving special attention to those having hydraulic laboratories; second, to study in at least one of these technical universities; third, to visit all types of hydraulic laboratories, including ship-model towing tanks; fourth, to visit the manufacturers of pumps and turbines; and finally, to visit the chief hydroelectric developments. In following this plan he visited the countries of Germany, Poland, Sweden, Denmark, Austria, Hungary, Italy, Switzerland, and France.

General Notes on the Countries Visited

It is impossible in the space available to relate all of the interesting and instructive things found in Europe during the past year, hence only a few high lights of the various countries will be given.

Gydnia. Gydnia is the Polish harbor and outlet to the Baltic at the head of the Polish Corridor. At the time it was visited the harbor, breakwater, piers, etc. were in process of construction. These piers were huge hollow concrete blocks which were poured on land near the shore. After the sand upon which they rested had been dredged out, the hollow blocks were easily floated to the place desired, pumped full of water, and allowed to sink. This formed a cheap, easy method of placing otherwise difficult engineering structures. However, infrequent visitors from Danzig saw these huge concrete blocks tilted into the water, and the rumor went about Danzig that the Poles were using them for fortifications and did not have enough engineering judgment to place them upon solid foundations.

Sweden. Sweden has three well-known manufacturers of hydraulic turbines: Kristinehamnwerkstadt, Kristinehamn; Finshyttanwerkstadt, Finshyttan; and the Trollhättan Engineering Works, Trollhättan. These were all visited and the author was very cordially received and shown through the plants by the engineers in charge. Trollhättan is not only the seat of the above-named engineering works, but possesses some beautiful falls, some locks on the Gota Canal, and a power plant which, in spite of its age of nineteen years, has turbines which give 88 per cent efficiency under a head of 29.7 meters and at a speed of 187.5 r.p.m.

The Gota Canal, an inland waterway right through the heart of Sweden, is several hundred years old, but each generation has added some improvements, so it is yet one of the outstanding engineering feats of the country.

Three days were spent in Goteborg visiting the technical college, the burgomaster or mayor of the town, and a few small pump manufacturers. It was the author's custom to call on the burgomasters of the cities visited because he had been given a letter of greeting to them from his home towns of Berkeley and Oakland, California. This was not only a great help but very interesting, because these men could always give first-hand information of the political and social conditions of their cities, and in case any difficulty was encountered in getting into the places where a visit was desired, they always knew a way of obtaining admission.

In Copenhagen, Denmark, the same procedure was followed. Here at the technical college was found an old electric generator which had been in continuous service from 1888 to 1924. A view and an account of this generator will be found on page 281 of the March 1, 1928, issue of *Power Plant Engineering*.

Germany. Hamburg, where is located the largest ship-model testing tank in the world (see May, 1928, issue of *Pacific Marine Review*, also "Hydraulic Laboratory Practice," 1929, published by A.S.M.E., p. 691) was next visited, and then Hanover, which has two hydraulic laboratories. The hydraulic-machinery laboratory under Professor Oesterlen was exceptionally well equipped. (See *Zeitschrift des Vereines deutscher Ingenieure*, vol. 70, no. 37, 1926, also "Hydraulic Laboratory Practice," p. 619.)

In Berlin are located three hydraulic laboratories, as well as a ship-model testing tank and many other things of interest to an engineer. (See "Hydraulic Laboratory Practice," pp. 245–300.)

Munich. After several months' study in the Technical University of Munich under Prof. Dr. Ing. D. Thoma, during which time visits were made to many interesting hydroelectric installations and to manufacturers of hydraulic turbines, pumps, hydraulic instruments, etc., the tour of inspection was continued through the beautiful cities of Vienna and Budapest.

Vienna. In Vienna there is a ship-model testing tank of exceptional merit, a governmental hydraulic-structures laboratory, a well-known manufacturer of hydraulic instruments, and a technical university which has a hydraulic-machinery laboratory and excellent lecture-demonstration equipment for teaching the hydraulics of rivers and harbors. (See "Hydraulic Laboratory Practice," pp. 305–335.)

Budapest. Budapest is a great surprise to the average Ameri-

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can, because he is not prepared to find a city of such beauty and charm. It too has a technical university with a hydraulic-structures laboratory used largely for instruction purposes, although some research work is carried on. (See "Hydraulic Laboratory Practice," p. 689.)

Italy. Italy, the seat of ancient Roman culture, was next visited. Most of the time was spent in picturesque Venice; Padua, the seat of the oldest university in the world (almost 800 years old) and of Italy's foremost civil engineering school; and Milan, noted not only for its cathedral but because it is the location of Italy's largest manufacturer of pumps and hydraulic turbines, and of her newest and most modern technical university.

One of the fine things accomplished in Milan by—and known as—"the work of young Italy," is the building of this technical

FIG. 1 TRAVELING SCREEN USED IN THE HYDRAULIC-MACHINERY LABORATORY OF THE TECHNICAL UNIVERSITY OF STOCKHOLM FOR MEASURING THE QUANTITY OF WATER FLOWING

FIG. 2 CAVITATION STUDIES ON A KAPLAN DRAFT TUBE AT THE STOCKHOLM LABORATORY

university. Here one finds a modern, well-equipped school where three years ago there was nothing except a barren field. A new hydraulic laboratory is being constructed there.

Switzerland. One could discourse for hours upon things in Switzerland of interest to engineers. Space permits only the mention of the excellent technical university at Zurich, where is being constructed one of the finest and most up-to-date hydraulic-structures laboratory in the world. The well-known firm of Escher, Wyss & Co., manufacturers of hydraulic turbines, steam turbines, etc., is also located in Zurich. This company has one of the best-equipped commercial laboratories the author has ever seen, and is now experimenting with tests upon hydraulic turbines, using air instead of water. This method is said to be faster and cheaper, and the company has recently accepted a large contract for an impulse water wheel upon which it has guaranteed 90 per

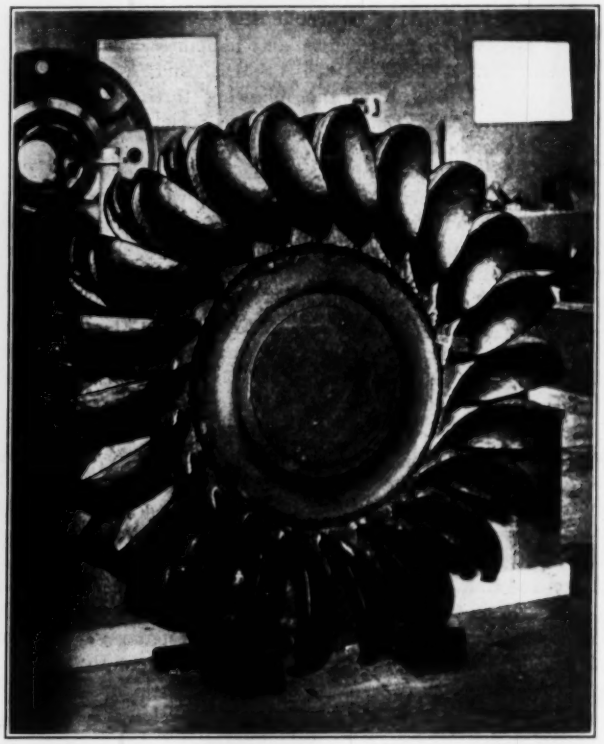


FIG. 3 CAST-STEEL IMPULSE-TURBINE MADE IN ONE CASTING

cent efficiency. Sulzer Bros., of Winterthur, are well-known manufacturers of Diesel engines and pumps of all kinds; and at Schaffhausen is the firm of Amsler & Co., which for several generations has been manufacturing testing machines and hydraulic instruments. These were all visited, and many interesting technical ideas were gleaned from this fertile field.

Switzerland is unusually rich in hydroelectric developments, and a fair number of these were visited. The Mühleberg plant about 1/2 hour's ride from Berne and easily accessible, is eight years old but very interesting. The power house forms a part of the dam, and in spite of its eight years of age there is not a crack of any kind to be seen, and the hydraulic equipment gives a maximum efficiency today of 86 per cent. There is room for two more units; the water must be pumped from the sweepage rooms because of the height of the tailrace water; the quantity of water is measured by current meters on the intake side; and there are automatic spillway gates which may also be controlled by hand. The plant is heated by air from the generators; all oil and water circuits are provided with sight indicators; and the dam is equipped with an energy dissipater very similar to the Rehbock *Zahnschwelle*, as well as with a special elevator required by the army engineers in order to make the stream navigable for pontoon boats in case of war.

France. One cannot make a trip to Europe and avoid seeing and hearing about some of the scars of the World War. In visiting Verdun, one who served during the recent war is sure to see

and note the resemblance of one of the gates of the city to the insignia of the Engineering Corps of the U. S. Army, and this gate, designed by the famous French military engineer Vauban, is in fact the original from which were designed the famous U. S. Engineers' castles.

INTERESTING HYDRAULIC DEVICES SEEN

In Germany, Sweden, Switzerland, and many of the countries of Northern Europe, one finds the "traveling screen" in frequent use as a means of measuring the quantity of water flowing. One

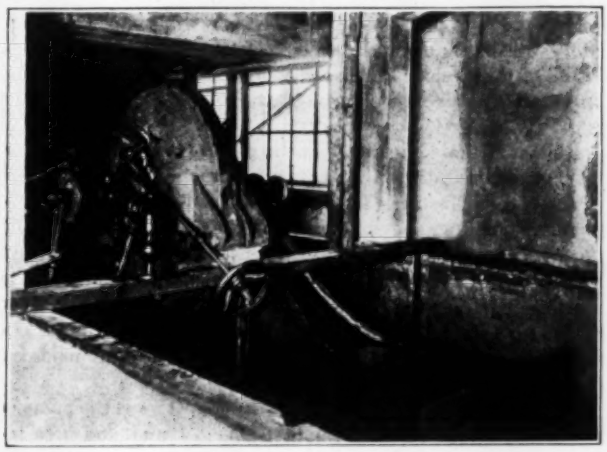


FIG. 4 TEST OF MODEL TURBINE AND SPECIAL DRAFT TUBE AT VOITH'S LABORATORY FOR THE PFROMBACH PLANT OF THE MITTLERE ISAR DEVELOPMENT. SCALE OF MODEL, 5:1, APPROX.

of the best of these screens is found in Professor Dahl's hydraulic-machinery laboratory at the Technical University of Stockholm, Sweden. Its principle of operation is simple. The screen (Fig. 1) may be flat or curved, and is mounted upon a truck provided with ball-bearing wheels which run upon a very carefully leveled track of known length. At the beginning of the measurement, the screen is gently but swiftly lowered into the water. As soon as it gains a uniform and steady speed it is timed between two or more known distances. This gives the mean velocity of the current in the channel, and since its cross-section is known, it is a simple matter to compute the quantity flowing. There are numerous refinements such as the use of a chronograph, electric contacts, automatic release at the end of the channel, etc., which cannot be described in this brief article.

Professor Dahl has recently conducted some researches upon cavitation possibilities with a Kaplan draft tube, Fig. 2, a draft tube little known or used in America. These researches have not been published, but various sources of information indicate that it not only offers simplicity and economy in construction, but that with many turbines it has a remarkably high efficiency without dangerous cavitation effects. The essential and distinctive features of the Kaplan draft tube are: first, it turns the water squarely through 90 deg., and second, it attempts to regain the energy by expanding the tube *after* the turn.

The Technical University of Stockholm has a hydraulic-structures laboratory in charge of Engineer Erik Lindquist. This laboratory is one of the most progressive and active research institutions in Europe, and has recently been engaged on the following problems: Tests on distorted models, flow in river models, scour at bridge pillars, pressure on dams, the model law for dams, the salt velocity method of measuring water, spillway energy dissipaters, prevention of log jams, etc.

River models are built up in the Stockholm laboratory as follows: After the model scale has been chosen and various cross-sections have been drawn out to that scale on paper, zinc strips are then cut from these templets and placed in the river-model flume at the proper distances apart. The distances between the strips are then filled in with concrete or plaster of paris. On a study made of the Hammersfarsen Dam in Northern Sweden to determine the most effective means of discharging logs over the dam at the lowest construction cost, the scale used was 1:200. The problem was solved in the laboratory at an approximate cost of $750, and the savings in construction costs over the original plans proposed were in excess of $100,000. (For a brief description of this laboratory, see "Hydraulic Structures Laboratory at the Technical University of Stockholm, Sweden," *California Engineer*, December, 1927, vol. 6, no. 4; and for a complete one see "Hydraulic Laboratory Practice," pp. 519–558.)

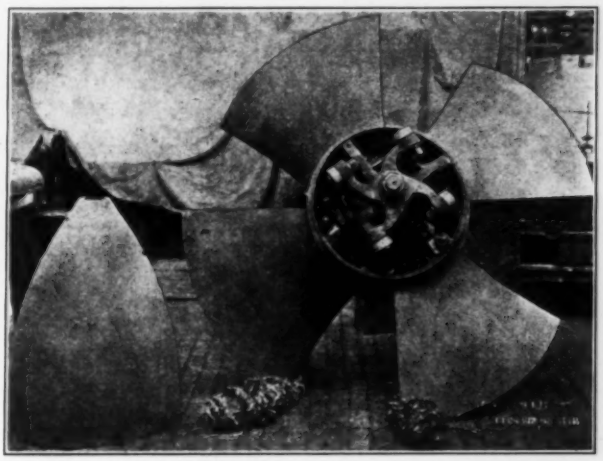


FIG. 5 RUNNER OF KAPLAN TURBINE, SHOWING MECHANISM WHEREBY GOVERNOR CHANGES POSITION OF BLADES WHILE TURBINE IS IN OPERATION

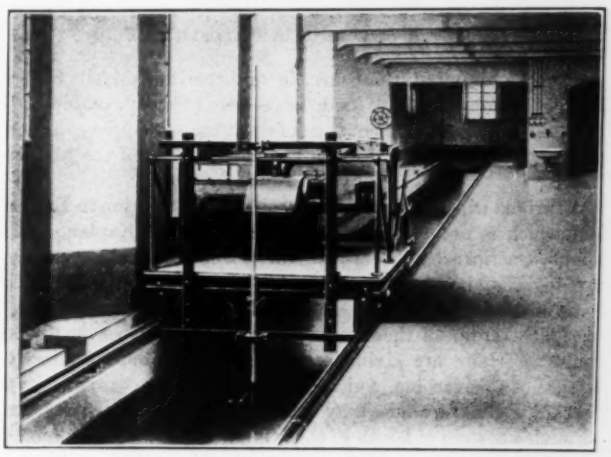


FIG. 6 THE OTT CURRENT-METER RATING LABORATORY AT KEMPTEN, ALLGAU, GERMANY, ONE OF THE FINEST OF ITS KIND IN THE WORLD

In the Hamburg Ship-Model Experimental Station, Hamburg, Germany (see "The Hamburg Experimental Tank," *Pacific Marine Review*, May, 1928), the models are first roughly cast in paraffin and then from drawings are accurately cut to the designer's profile by an ingenious machine. Afterward the models are tested in the large towing tank.

An interesting impulse runner was on exhibit at the Engineering Materials Exhibition in Berlin in October, 1927. It was made of

cast steel and though highly polished was not painted, which afforded an opportunity to see that it was almost a perfect casting. It was about $4^1/_2$ ft. in diameter and had twenty-two buckets about 12 in. in width. A view of this runner is shown in Fig. 3.

The use of riveted sheet steel for reaction-turbine housings is practiced to a considerable extent in America, and it is now quite common in Europe. J. M. Voith, of Heidenheim, Germany, makes a double-acting governor which has attracted considerable attention and one of them has given entire satisfaction in the Aachensee plant near Jenbach, Austria. Voith also has an

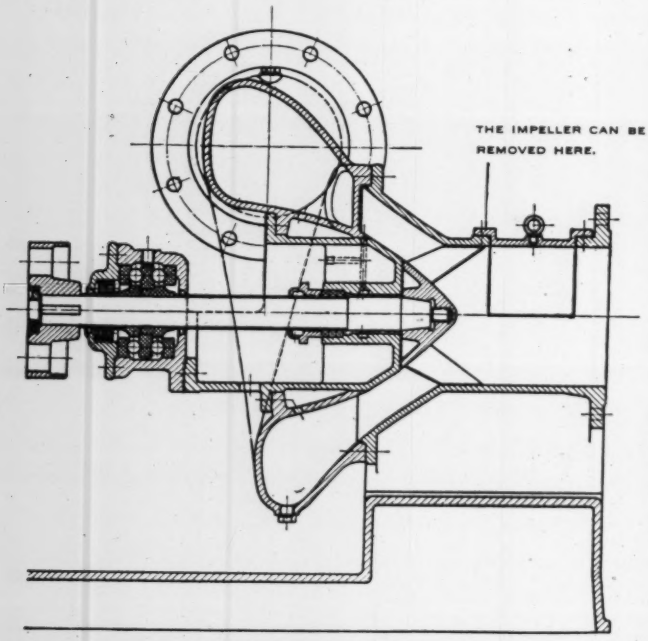


FIG. 7 A SWEDISH SCREW-PROPELLER PUMP

excellent hydraulic-turbine testing or experimental laboratory. In this laboratory, Fig. 4, model tests were recently conducted to determine the most efficient type of draft tube to employ with the turbine runner designed for the Pfrombach plant of the Mittlere Isar.

A turbine which is attracting considerable attention in Europe, and which is not yet in use in America, is the Kaplan. Well might American engineers give this turbine some thought and investigation, because there are many of them in use in Europe in some of the largest plants. In fact, there are at present installed over 300,000 hp. of these turbines, and all, as far as the author could ascertain, are giving satisfaction. The most distinctive feature of this turbine, which is essentially of the propeller type (Fig. 5), is that its blades may be shifted by means of the governor through a system of levers so that they will at all times be maintained in their most efficient position regardless of the load or quantity flowing. This turbine was discussed in the author's paper, "Some Interesting European Hydraulic Turbine Research," at the 1928 A.S.M.E. Annual Meeting.

The firm of Ott, at Kempten, Allgau, Germany, is well known for the manufacture of planimeters and hydraulic instruments of all kinds. It also has the best current-meter rating station the author has ever seen. (Fig. 6.) Not only can the rating car be handled under all velocities up to 15 ft. per sec., but its operation is exceptionally smooth and the tank is so constructed with glass walls that the action and position of the meter may be studied at all velocities. The Ott meters, which are horizontal-axis meters, will not rotate in still water when moved up and down and do not rotate in the same direction regardless of the direction the water is flowing. As a result, the current-meter method of water measurement is highly regarded by the engineering profession in Europe. It is used extensively in large conduits. As many as 27 different current meters have been used at one time with one chronograph for one large conduit in measuring water.

A discussion of European hydraulics would not be complete without mention of Prof. Dr. Ing. D. Thoma's excellent laboratory at the Technical University of Munich. Probably no other laboratory in the world has published so much research work in the last two years. A complete description of this laboratory will be found in an article entitled "The Hydraulic Institute of the Technical University of Munich, Germany," in the *Purdue Engineering Review*, vol. 23, no. 3, March, 1928, as well as in "Hydraulic Laboratory Practice," pp. 435–475.

Another hydraulic institute in the neighborhood of Munich is the Forschungsinstitut für Wasserbau und Wasserkraft. (See "The Research Institute for Hydraulic and Hydroelectric Structures," MECHANICAL ENGINEERING, vol. 50, no. 8, August, 1928.) This institute, under Dr. Ing. Otto Kirschmer, has shown that current-meter measurements accurately and carefully made should not be out more than $^2/_{10}$ of one per cent. It has also carried on experiments on the relation between the results obtained in model tests of hydraulic structures and those made on the full-scale structures.

Besides being a most beautiful city, Budapest was the home of the famous professor of hydraulics, Donat Banki, and here today turbines invented by him are being manufactured by his son. The Banki turbine, its theory, advantages, etc., have been discussed in the paper "Some European Hydraulic Turbine Research." It is a cross-flow turbine, using both the principles of impulse and reaction. It is simplicity itself, and although not adapted to extremely large installations, offers an efficient and cheap solution to the consumer of small quantities of power.

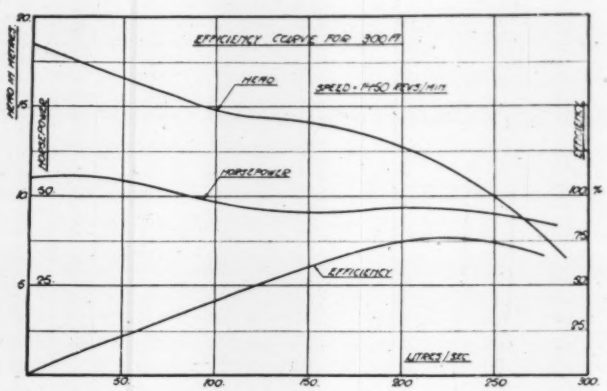


FIG. 8 CHARACTERISTICS OF SCREW-PROPELLER PUMP SHOWN IN FIG. 7

Even when submerged this turbine continues to operate with the same maximum efficiency.

The Riva Construction Co. of Milan, Italy, is the chief hydraulic-machinery research institution now at work in Italy.

In France, most of the hydraulic-machinery investigations have been carried on by the Société Hydrotechnique de France. This laboratory, under the direction of M. Leroux, is known as the "Laboratoire D'Essais de Beauvert," and is located in Grenoble, France. It is one of the largest laboratories in the world.

Very little new and interesting was found in Europe of interest to hydraulic engineers concerned with pump problems. Several

manufacturers are manufacturing and experimenting with high-speed, high-head centrifugal pumps. One such pump was seen which lifted water 450 ft. in a single stage. Some novel experiments were being carried on to discover ways of eliminating the cavitation which results from this high-speed operation.

Deep-well turbine pumping as practiced so extensively in the western part of the United States is little known in Europe.

A combination screw-propeller pump of interest to American engineers is manufactured in Finnshyttan, Sweden. This pump (Fig. 7) greatly resembles the Moody pump manufactured by the I. P. Morris Co. Its characteristics are shown in Fig. 8.

THE KARLSRUHE HYDRAULIC-STRUCTURES LABORATORY

One of the best-equipped, best-managed hydraulic-structures laboratories in the world today, is the one at Karlsruhe Technical University, which is under the direction of Prof. Dr. Ing. Th. Rehbock (see "Hydraulic Laboratory Practice," pp. 109–242), who is soon to give a series of lectures on river hydraulics at the Massachusetts Institute of Technology. For many years this laboratory has been engaged in the solution of river-control problems from all over the world. The study of backwater around bridge piers, the evolution of a new wier formula (the Rehbock formula), and the discovery and development of an energy dissipater for spillways (the *Zahnschwelle*), etc., constitute only a few of the many great researches of this laboratory. One of the recent discoveries in connection with the experimental work on straightening the Rhine between Germersheim and Speyer was the use of a volcanic pumice for the river bed instead of the regular sand. (See "Der Einfluss der Korrektion des Rheins zwischen Basel und Mannheim auf die Geschiebebewegung des Rheins," von Dipl. Ing. H. Wittmann, *Deutsche Wasserwirtschaft*, Jahrgang, 1927, Heft 10–12.) Formerly quartz sand as found in the river (see Fig. 9) was used for model experiments. This when used on models of a scale of 1:200 gave results as shown in the figure, which are not the same as the phenomena which nature produces. The material used in Fig. 10 was a pumice of volcanic origin which was carefully selected by a sluicing process, and only that material which was washed through the sluicing channel was used in the tests. It had a uniform specific gravity of 1 to 1.2. The model here shown was constructed on a scale of 1:200. The slope in the model, which is 1:500, is greater than the corresponding slope in nature, but this is necessary in order to make the velocities in the model bear the proper relations to those in nature as required by the law of hydraulic similarity.

FIG. 9 MODEL STUDIES IN HYDRAULIC-STRUCTURES LABORATORY AT THE TECHNICAL UNIVERSITY, KARLSRUHE, GERMANY

(Heavy, coarse sand was used in this test on the Rhine River, near Germersheim. Note the large ripples not found in nature or in the full-scale river.)

Fig. 9 shows the bed of the stream after a test of one hour's duration at a discharge corresponding to 210,000 cu. ft. per sec. in nature. The material forming the bed was quartz sand which had a maximum grain diameter of 4 mm. The sand ripples here seen are characteristic of those formed in models when ordinary sand or gravel is used. The moving banks and other phenomena found in nature are not reproduced in a model with such material.

FIG. 10 MODEL STUDY OF RHINE RIVER NEAR GERMERSHEIM, USING LIGHT VOLCANIC PUMICE SAND. SCALE, 1:200

(View shows condition of model river bed after 10-hr. flow of quantity corresponding to 210,000 cu. ft. per sec. Moving banks shown are quite as they occur in nature.)

Fig. 10 shows the same model using pumice, and with the spur dikes as they exist in nature, after a test of ten hours' duration at the same rate of discharge, namely, a quantity proportional to 210,000 cu. ft. per sec. The moving banks are here observed in the model as they appear in nature, yet the maximum grain diameter of the pumice was but 6 mm. This is a very valuable contribution to the science of river-control experimentation.

As a John R. Freeman Scholar of the A.S.M.E., the author attended all of the lectures given at the Technical University of Munich by Prof. Dr. Ing. D. Thoma for one semester, visited ten countries, 42 cities, 37 hydraulic laboratories, collected many minor technical ideas, and wrote 11 articles for technical periodicals totaling about 25,000 words. These things were made possible by the A.S.M.E. and the generosity of Mr. J. R. Freeman, to whom grateful acknowledgment is here made for all that is good in this or similar contributions to the Society.

Preferred Numbers[1]

Advantages of the German Series of Preferred Numbers (DIN 323) in the Establishment of Series of Sizes of Finished Products—Particulars Regarding Their Use by German Industrial Concerns

By PROFESSOR DR. C. VON DOBBELER, KARLSRUHE, GERMANY

IN ORDER fully to understand the possibilities of applying the preferred numbers as given on DIN 323,[2] it is necessary to be conversant with the history of the development of this standard sheet. One of the first sheets issued by the German standardizing body was DIN 3, giving the so-called "standard diameters." This sheet was established by canvassing all industries concerned with respect to the diameters most commonly used by them and listing those having the greatest frequency of use. DIN 3 has given full satisfaction and has been extensively introduced. However, it contains no less than 70 different diameters between 1 and 100. This large number of diameters compels many firms to make a selection from this series in order not to be obliged to keep in stock an excessive number of gages, tool holders, etc.

This condition led to the proposal that the German national standardizing body establish certain standard rules for making such further selection, that is, for designating certain values within the series of diameters as "preferred" or as "specially preferred."

The feasibility of extending these rules to cover linear dimensions was investigated and led to the plan of supplementing the "series of diameters" by a second sheet for general construction dimensions, or sheet of "preferred numbers," as it was later called.

At the same time the obvious dependence of the size of a part upon the size of the whole machine made it appear necessary to take into account, in establishing standards for basic and semi-finished products of any kind, the laws underlying the establishment of series for the finished products, and furthermore, in order to be consistent, to base the design dimensions themselves on such laws.

If, for example, a series of 20 motor types is designed, then it is inadequate for the corresponding series of bushings to comprise but 18 types; 20 different types must be provided, except in cases where several motors use the same type of bushing, when 10 or even 5 types may be sufficient. In any case the series of bushings is strictly dependent on the series of finished products.

If, therefore, a special selection of dimensions for general design purposes were to be made from the series of diameters, this would have to take into account the laws underlying the establishment of series of finished products, so that the values selected would be preferred design dimensions in general, applying both to lengths and diameters. The basic idea of this procedure is that any new design of an individual unit should be dimensioned from the start on the basis of the preferred numbers, so that later on the unit would automatically become a properly coordinated member of a systematic series, if this were subsequently developed.

To be entirely consistent this systematic series should be applicable not only to essential dimensions of the parts which are being designed, but also to abstract or complex quantities such as speed, current consumption, rating, or voltage of the completed machine. In such cases one cannot speak of "preferred sizes," but should use the more general term "preferred numbers."

Evidently, in establishing a standard for preferred numbers, there were quite a number of, and to some extent very different, points of view to be considered at the same time. They may be summarized briefly as follows:

1 Reduction of the number of sizes in general, and particularly

- *a* Selection of diameters from the series already in existence
- *b* Establishment of a series of suitable standard lengths, widths, etc.

2 Adaptation of the preferred values selected to the existing principles for the establishment of standard series of finished products.

3 Suitability of the preferred numbers for the establishment of series of new standard parts ("typification"), and particularly

- *a* For the dimensions of the standard parts
- *b* For the other numerically expressed properties of the standard parts (for example: capacity, strength, weight, etc.).

I—Reduction of Number of Sizes

The first requirement, reduction of the number of numerical values or sizes, is obvious as it means at the same time a reduction of the measuring devices, tool-holding devices, component parts, etc. This requirement is therefore entirely consistent with the tendency of standardization in general. On the other hand, however, a reduction of the number of sizes available usually renders the work of the designer more difficult by requiring him to select his dimensions economically from the reduced list of sizes. Increased difficulty of design, however, is justifiable provided it is offset by increased economy of manufacture.

A far more important question is the amount of waste produced by reduction of the number of available sizes.

In the so-called "40 series," the difference in size between two consecutive terms is approximately 6 per cent. The designer may therefore occasionally be obliged to round a dimension, calculated on a theoretical basis, upward or downward, by an amount up to 3 per cent. A characteristic of the geometric series is that its chance of striking on the theoretically exact figure is constant throughout. Consequently it is impossible that in the "40 series" there shall ever occur deviations from a value calculated on a theoretical basis exceeding the 3 per cent just mentioned. This 3 per cent applies exclusively to linear dimensions. For volumes, cubic contents, or weights it would correspond to a deviation of $(1.03)^3 - 1$, or approximately 10 per cent in the most unfavorable case. A waste of material up to 10 per cent is therefore possible. In the so-called "20 series" the difference in size between two consecutive terms is twice as large, which condition leads, in the most un-

[1] A paper by Myron E. Steczynski presenting a series of preferred numbers believed to be better adapted to American practice than those now used in Europe, appeared in the November, 1928, issue of Mechanical Engineering.—Editor.

[2] The German standards are issued in the form of sheets, each bearing a symbol "DIN" (which means German Industrial Standard), followed by a number.

favorable case, to a waste of material of approximately 20 to 22 per cent. However, this excess consumption of material is counterbalanced by a reduction in the number of necessary measuring devices in a ratio of approximately 70 to 40 (corresponding to DIN 3 having 70 steps, and DIN 323 having only 40). No doubt there are cases in which an increase in weight is entirely immaterial as compared to the saving in measuring devices. On the other hand, there are also cases in which such increase in weight is not permissible, purely for reasons of design, especially when a maximum saving in weight is imperative for technical rather than economic reasons (as for example, in airplane and automobile design).

As an example of the latter case, the standardization of carburetor flanges for automotive vehicles may be mentioned. In standardizing carburetor flanges, the German Trade Standards Committee for the Automotive Industry was bound by the distances between bolt holes which had been introduced into the automotive industry several years ago by standardization work done during the war. The sub-committee for carburetors found that the oval shapes according to DIN 251 when applied to the existing nominal sizes of carburetors and the distances between their bolt holes, gave no suitable results, as a considerably larger amount of material (up to 40 per cent) would go into the carburetors. The Trade Standards Committee of the Automotive Industry was therefore obliged to establish a special shape of flange based on the existing nominal dimensions and bolt-hole distances, the thickness of the suction flange, the width across flats of the connection bolts, and a certain shape of the flanges making for tightness of the joint; the latter being the result of the experience of the carburetor manufacturers.

These flanges were approved by the carburetor and automobile manufacturers, but objected to by the German national standardizing body before they went to press in final form. On the basis of these objections the Trade Standards Committee of the Automotive Industry, in cooperation with the NDI, went over the flange sizes in question again, bringing them in line with the DIN oval shapes by rounding the length of each carburetor flange to the next larger dimension appearing in the series of DIN oval shapes. The result was that the lengths of all of the carburetor flanges were in accordance with the lengths of the NDI flanges. As to the widths, uniformity in size with regard to the standard series of oval shapes could be reached in but 4 out of 9 cases, the remaining 5 cases showing a deviation from the preferred numbers which was not avoidable. This change in the original flange sizes of the automotive industry in order to adhere to the preferred numbers meant an increase in weight of 10 to 15 per cent, which no doubt in the present cases was a very considerable one.

In cases where the so-called "40 series," with a maximum possible deviation from the target of 3 per cent, is too coarsely graduated, numerical values can be employed which are taken from the so-called "80 series." The extension of the standard for preferred numbers by adding an "80 series" is under consideration. This additional series, however, should be used only in case that a suitable value in the "40 series" cannot be found.

The example mentioned above shows that an unconditional application of preferred numbers is not always possible, but that in the very large majority of cases preferred numbers can be used.

II—Adaptation of Selected Preferred Numbers to Existing Laws Governing Type Series of Finished Products

The second of the requirements enumerated above relates to the adaptation of the selected preferred numbers to the existing laws governing type series of finished products. An objection raised against this requirement is that such laws vary so greatly that it is not even possible to design the individual basic and semi-finished products on this plan.

As to the design dimensions of the final product, their adaptation to the laws governing the sizes of finished products would therefore be entirely out of the question, according to these opponents. It was therefore proposed to drop this purpose entirely and to select the preferred numbers simply from values already introduced to a certain extent into actual practice. For example: the gradations 10, 20, 30, 40, etc., 10, 15, 20, 25, 30, 35, etc., or again 10, 12, 15, 18, 20, 22, 25, 28, 30, etc.—the latter being a gradation on the basis of the final digits 0, 2, 5, 8—are frequently used. Such gradations have been established through adaptation to the decimal system and can easily be kept in mind.

If the selection were to be made on the basis of the system 0, 2, 5, 8, a large number of values subdivisible only with difficulty would be obtained. Moreover, the gradation 0, 2, 5, 8 possesses the very great disadvantage that all numbers ending in 5, in case they have to be halved, inevitably give rise to fractions. On the other hand, such a series is also unwieldy with regard to making additions, the sum of 2 and 5, and of 5 and 8, etc., always giving values which are not included in the preferred-number series. This is important as additions are unavoidable in using dimensions of length. In fact, no sound arguments can be brought forward in favor of the gradation 0, 2, 5, 8, with the exception of only a doubtless very important one, namely, that it has been adapted to the decimal system. It can be said that the gradation 0, 2, 5, 8, which was already in existence, was the real source of all objections raised against DIN 323. Practically all of these objections can be condensed into the following consideration: "We have, unfortunately, the decimal system, and in accordance with this the gradation 0, 2, 5, 8. Therefore if a reduction of the number of available sizes is necessary, such reduction should take place on the basis of this existing gradation."

III—Suitability of Preferred Numbers for the Establishment of New Standard Series

The third requirement, to the effect that the preferred numbers shall also be suitable for the establishment of new standard series, is after all the most important one. In fact, if this requirement is considered to be justified and practicable, then also the first and second requirements must be considered as justified. In this respect the first question which arises is: According to what laws shall a technical standard series of sizes be built up?

As is already known, the preferred numbers are gradated according to a geometric series, the characteristic advantages of which are known. Also, geometric series have been used for a long time for the establishment of standard size series. An error which is commonly made may be pointed out here. It is often assumed that a geometric series always results in products which are geometrically identical, an assumption which is not correct. It is quite possible to design parts which are geometrically similar without using a geometric gradation, and on the other hand, a geometrically gradated series can be built up without this necessarily meaning that the resulting bodies are geometrically similar. Geometric similarity and a geometric series have nothing to do with each other, but the two ideas are often confused. The distinction between the two is shown by the following example, which at the same time characterizes the intended application of preferred numbers. This example relates to the establishment of a series of hollow cylinders. Let it be assumed that the following values are chosen for their dimensions:

Diameter in mm.	125.8	125.8	141.2	141.2	158.5	158.5	177.8 etc.
Height in mm. . .	200	251	251	316	316	398	398 etc.
Content in liters.	2.47	3.10	3.91	4.97	6.23	7.90	9.80 etc.

These numerical values have been taken from the exact geometric series which is the basis of the preferred numbers as given on the standard sheet, without being rounded to any considerable extent. It will be seen that the individual hollow cylinders are not at all geometrically similar. Nevertheless, the series of contents is an exact geometric series in which each term is about 26 per cent larger than the previous one. It is therefore obvious that, especially for such bodies as are not geometrically similar, it is particularly advantageous to select dimensions belonging to a geometric series of numbers, as this automatically results in the performance figures (in this case the contents) falling into a geometric progression.

It is a well-known property of a geometric series that the percentage difference between two consecutive terms is constant. This feature is emphasized by many as a special advantage of the geometric series. However, one can imagine many cases in which a different rate of increase is desirable, and an endeavor has therefore been made to use also series other than geometric ones in designing standard parts. This would perhaps be possible if the constant increase in percentage were the only argument for the preference of the geometric series. However, there is another condition which also leads automatically to the use of geometric series. This may be shown by the following example.

Let us assume that a series of electric motors is to be established. This will be done by starting out from a certain motor with a certain diameter and a certain length of armature. If larger motor capacities are required, the diameters are maintained and the longitudinal dimensions are increased. In this way it will be possible to establish perhaps two or three motors with the same diameter before a practical limit for the longitudinal dimensions is reached; it will then be necessary to start a second series with a larger diameter. In establishing this second series an effort will be made to use as much as possible the same longitudinal dimensions as were applied in the series of motors with smaller diameters. In this way the entire series of standard motors finally consists of a number of small series each containing two or three motors with the same diameter, but different longitudinal dimensions. The ratings of the units of such series must obviously all be different, as there is no advantage in having two different forms of product with approximately the same rating. Furthermore, the series of ratings must show a certain regularity without being rigorously gradated according to a certain law. The considerations just mentioned do not apply to electric motors only, but also to many machines of different kinds. Thus, for example, the diameter and stroke are the features which are of particular importance for piston engines. Consistent adherence to the principle that the same dimensions are to be used in the largest possible number of cases, *will automatically lead to the selection of the dimensions from a geometric series of numbers, even if there was no intention of adopting a geometric series for the rating figures.*

A mathematical proof of the fact that the dimensions must be selected from a geometric series if it is desired to obtain a regular series for ratings with a minimum of different sizes, that is, with a minimum of component parts, can be given, but will not be shown here. It is not possible to obtain any regular series if the dimensions are not selected from a geometric series. This means also that in such cases in which perhaps a gradation other than a geometric one might be approved for certain reasons, the adoption of a geometric series is imperative as otherwise the required component parts cannot be used for several sizes of machines. Only a geometric series gives a minimum of component parts. Of course, this only applies to such products as motors, which are composed of several sub-units. For products which are not built up of parts, for example, a series of gages, this reasoning does not apply. Therefore, in the first place, all those industries whose field includes products which are built up of component parts, have benefited by the advantages of the geometric series, while on the contrary, firms manufacturing non-fabricated parts exclusively, have not been able to discover any immediate advantages by applying a geometric gradation. A few examples of the application of the series according to DIN 323 may be given here.

An electrotechnical firm, the Bergmann Elektrizitätswerke, of Berlin, has established the ratings of its three-phase motors from 10 kilowatts up in accordance with the 10 series.

Under date of April 20, 1926, this firm wrote as follows:

Before standardization, we had extended the widths on the basis of an arithmetical series. However, this resulted in ratings without systematic correlation. In case generators with a rating different from the standard ratings were required, we supplied the standard machine with the next larger rating, in some cases with a slightly reduced weight of steel and copper. This typification has proved very satisfactory throughout, the main reason being, in our opinion, that the diameters (of the sheet-metal housings) were gradated many years ago according to a geometric series. This series does not conform to DIN 323, as it existed a long time before this standard was issued, and as a change in these diameters would cause considerable unjustifiable expense necessitated by the procurement of new cutting tools in addition to the old ones.

We realize, however, that the standardization of this series of ratings, and particularly that of the transmission of power to the driven machines, is accompanied by great difficulties. For example, the standardization is based on a frequency of 50 cycles. If the frequency is changed to 60 cycles—a change required by many deliveries to foreign countries—the rating changes correspondingly and therefore does not constitute a preferred number. In order to adhere to such preferred numbers, it would be necessary to change the width of the machine, which procedure would, however, create a superfluous new type. Furthermore, one has to deal with the use of generators in the tropics where the ratings are proportionately lower because of lower permissible temperature rise of the generators, so that deviations from the preferred numbers also occur in this case.

The transfer of the preferred capacities to the prime movers also introduces further considerations. The ratings of the prime movers are usually given in horsepowers; those of generators, however, are given in kilowatts. Furthermore the ratings of the generators are often chosen larger than those of the prime movers, as after all the rating of a prime mover can be increased by changing to a higher steam pressure, adding more cylinders, or, in gas engines, by introducing scavenging processes. In all of these cases it is desirable that the generators shall be able to produce the increased rating without changes or additions. In this connection, then, the kind of prime mover governs the solution. For example, in steam engines a distinction is made between the normal rating at the most favorable degree of admission, the long-run maximum rating, and the short-run maximum rating. In general, the generator is given nine-tenths of the rating of the steam engine. On the other hand, however, in the case of non-condensing steam engines, where the exhaust steam is used entirely for heating purposes, the generator rating is made equal to the long-run maximum rating of the engine. Gas engines, however, cannot take an overload. Therefore a generator driven by a gas engine is given about 0.95 of the gas-engine rating, and in the case of Diesel engines the rating of the generator is often made equal to the full capacity of the engine.

All of these viewpoints would have to be taken into consideration in using preferred numbers in a general way for the establishment of standard series of ratings. A general solution of such standardization is therefore hardly possible. Since the main advantage of geometric series is that, if used in connection with other geometric series, they always give geometric series again, it is quite disadvantageous in the standardization of a series of capacities that the r.p.m. cannot be gradated on the basis of geometric series because of their dependence on the number of poles of the generators. The r.p.m. resulting therefrom, viz., 83.5, 94, 100, 107, 115, 125, 136, 150, 167, 187, 215, 250, 300, 375, 430, 500, 600, 750, 1000, 1500, and 3000, are gradually being accepted as standard speeds throughout the entire electrical-machine industry. However, all frequencies above or below 50 require higher or lower r.p.m. ratings. It will be clear from these considerations that the ratings should not be the main

thing, and therefore do not constitute the most favorable theoretical basis for establishing standard ratings by means of preferred numbers. Nevertheless, we have used the latter in the new set-up of our generators in correlation with the standards for motors as a point of departure for the size-standardization work, and we have found that the 10-series complies with the practical requirements so that intermediate terms can be done away with.

The Hahn and Kolb Index-Werke, of Esslinger-Neckar, communicated the following experience:

In introducing standard pulley diameters and speeds we have not experienced any difficulties, as we based our standards on the uniform r.p.m. chosen once for all for our transmissions (250), and in each case chose the next larger suitable pulley diameter in order to obtain approximately the desired r.p.m. of the machines in question. Obviously it was not possible, in most cases, to obtain to a close approximation the r.p.m. series of the machines as given by their manufacturers on r.p.m. tables supplied with the machines, because of the relatively large steps in the pulley diameters. However, this was of no particular interest to us as in the large majority of cases we adopted different r.p.m. anyway in connection with the particular work to be done by the machines, such speeds fitting our requirements better than those indicated by the manufacturers of the machines. The tables supplied by them were consequently eliminated in most cases and replaced by our own which are used both in the workshop and combined into folders for the computation of operation time per piece.

The Union Machine-Tool Works of Chemnitz wrote as follows:

Up to the present we have applied preferred numbers to a limited extent in designing our series of drilling machines.

The 80-series provides in many cases a suitable means of establishing in a quick and simple manner individual dimensions in geometric progression. Thus, for example, we have established the dimensions of our drilling-machine tables by selecting them from the preferred-number series. (See table below.)

Number	1	2	3	4	5	6
Width in mm	500	560	640	720	800	900
Length in mm	640	720	800	900	1000	1100

The same procedure can be followed in gradating quite a number of essential dimensions of the machines in question. In doing so it will not always be necessary to adhere to same gradation; it may well be possible to apply a coarse gradation for one dimension of a part and a finer gradation for another dimension. This will always lead quickly and surely to a suitable series, and therefore to the good appearance of the entire series of machines.

Another example, omitted for lack of space, shows that a geometric series is produced, as it were, automatically, even in cases where there was no intention of obtaining a gradation of this kind at the time the design was developed. Therefore it would seem as if the geometric gradation represented, as it were, a general law which is actually though unconsciously observed by the designer. Also, in the past geometric gradations have been applied more or less unconsciously in designing series of sizes of different objects. In fact, if one has to design a larger size of a type for which there is an existing smaller size, he will unconsciously make the new size a definite percentage larger than the existing one. In conclusion, it may therefore be said that the distinct preference shown for the geometric series is not a matter of chance, but that there are essential and logical, and therefore compelling, reasons for its selection.

It cannot be denied that in many cases gradations other than geometric are unavoidable, Thus, for example, the r.p.m. series for alternating-current motors depends on the number of poles, while the series of pole numbers must of course be an arithmetical series, to wit: 2, 4, 6, 8, 10, etc. The same conditions may present themselves in other cases, which, however, must always be considered as special cases devoid of any fundamental general validity, whereas the geometric series, as shown above, is actually based on several general principles.

The advantages of the geometric series are generally recognized. This, however, does not mean that the particular geometric series forming the basis of the preferred numbers is the best one. It might be possible that several geometric series could be established with equal justification, a selected one among these series being applied because of its special suitability to the design of a specific series of types. Such an assumption would be a false one, as it does not take into account the interdependence of the individual standard series.

The series of sizes of standard parts are dependent upon each other, or at least on a common third series, so that it is very often necessary to take into account the connection between different series which was not obvious at first. A particularly striking example is the interdependence of series in the standardization of pulley diameters and r.p.m. In this case even small deviations of only a few per cent were inadmissible. As the series of r.p.m. depends directly on the series of motor ratings, and the latter again (as far as electric motors are concerned) on the series of current intensities and voltages, there is here an actual connection between the series of pulley diameters on the one hand, and the series of current intensities on the other, whose existence doubtless would not be suspected at first glance. Such interdependences, hidden at first, must exist between a large number of other entirely different standard parts. Therefore the individual series mesh like the teeth of gears, and just as it is impossible to have gears with a different mesh and pitch work together in a correct manner—even if each individual gear has been made in as exact a manner as possible—to the same extent individual preferred-number series will not fit together if they are based upon a different gradation.

In conclusion the following can be said:

A series of sizes of finished products must be built up in such a way that the same component parts can be used for the largest possible number of different products. The mathematical maximum possibility of use of the individual parts can be attained only when the individual parts, or their dimensions, have been selected from a geometric series.

The geometric similarity, however, is of no importance in this respect. The geometric gradation is therefore a mathematical law of universal validity for the economic establishment of a series, while in individual cases special laws may have to be observed in establishing one. In such cases the maximum economy cannot be attained.

Because of the interdependence of standards it is not possible to use geometric gradations on several different bases, side by side; a uniform or standard mode of gradation is essential under all conditions.

Myron E. Steczynski states that "it is indicated that what American industry needs is not so much a mathematical series of computed numbers as a logical arrangement of all computed numbers."[3] This view must be decidedly contradicted, since the necessity for the geometric series, as shown, is a natural law which cannot be ignored without entailing harmful consequences. If the geometric series is not selected as a standard, it matters very little which one is, since every other series will in a few years lead to contradictions.

In so far as the preferred numbers as given on DIN 323 are to be used as individual dimensions for purposes of design, small deviations and changes become necessary occasionally in order to conform ot existing standard values. Difficulties are caused less by the principle according to which the preferred numbers have been selected, than by the limitation of dimensional values available in general. In establishing series of sizes, the preferred numbers given on DIN 323 have proved to be extremely suitable in practically all instances where applied.

[3] MECHANICAL ENGINEERING, November, 1928, p. 851.

Limitations of Standardization[1]

A Readable Statement, Presenting Specific Examples, by One Who Has Had Experience

By K. GRAMENZ, BERLIN, GERMANY

STANDARDIZATION more and more becomes an essential factor in the industrial production of goods and transportation. The more the field of standardization expands, the more frequently it is asked, "How much farther will standardization go, and what are its limitations?"

Although standardization in the widest sense of the word may be said to be universally applicable, the following considerations concerning its limitations will refer to consumers' goods exclusively, and more particularly to technical consumers' goods. For such goods the purpose of their use, and not taste or fashion, is the controlling factor, and therefore it must be possible to find a most efficient form of execution, a most economical manufacturing process, or—with respect to materials—a composition guaranteeing the best properties. It would seem at the first glance that in these circumstances standardization is not subject to any limitations and that unification can be carried to the extreme. However, it will be seen from the following that even standardization is not able to free itself entirely from tradition, and that even here it is not possible to avoid entirely human shortcomings and a sound individualism. We should not bar the way toward further technical progress, nor abolish the stimulus of competition. Also, we must realize that technical shortcomings and conditions which simply cannot be fulfilled, create boundaries which we cannot trespass.

The ever-increasing need of standardization is a result of the tendency toward a better-planned system of procuring goods. Standardization must aid in reducing the cost of production and transportation of goods. A standard should therefore in the first place foster economy. Otherwise it either hampers economic progress or remains a "paper standard." This fundamental requirement with which a standard must comply is sufficient to indicate the limitations of standardization.

Standardization cannot disregard tradition without serious loss through the wiping out of tremendous investments. Also, standardization cannot simply abolish certain existing forms in the economic structure; it can only influence the functions and effects of the latter. Nor can standardization change technical considerations overnight; it must let experience ripen in the course of time. Personal views, based on experience and local conditions, cannot be forced. The road of technical progress must be left free. Standardization must not eliminate sound competition, but only do away with unjustifiable and uneconomical variety. Technical inability makes itself felt in matters of standardization, with regard to the limits of dimensional accuracy and the production of engineering materials.

It is obvious that an investigation into the limitations of standardization cannot lead to a general conclusion or to rules suitable to be expressed in a few concrete formulas. The question as to where standardization finds its limitations, can be studied by the aid of specific examples only. It must be kept in mind that all considerations are based on our present point of view, and that time, technical progress, and changes in the economic conditions will modify relationships and shift the limitations of standardization.

Tradition

An exceedingly illustrative example of how standardization can find its limitations by tradition is supplied by the standardization of screw-thread systems. In Germany, standards for the Whitworth thread strictly conforming to the English original, and for the metric thread have been established. The two systems do not show essential differences in their ratios between pitch and diameter, nor has the 55-deg. angle of the Whitworth thread any technical advantage over the 60-deg. angle of the metric thread, or conversely. Consequently there are no technical grounds which would prevent the establishment of a unified standard. The Whitworth thread with its diameters and pitches expressed in inches, will always impress people in metric countries as a foreign system, but nevertheless it has become deeply rooted in German industry by convention. There are enormous stocks of tools and gages—in the first place those intended for unusual and therefore expensive sizes which do not call so soon for replacement. Replacement parts with Whitworth threads must be supplied for years to come, and the export of machinery to countries having the inch system is another factor to be considered. It is therefore obvious that at least at the present time there would be serious difficulties in changing over to the exclusive use of metric threads.

The existence of two different screw-thread systems is particularly unfortunate with regard to the standardization of bolts and screws. The German national standards comprise about 50 sheets on screws with Whitworth threads and about 70 on screws with metric threads. Consideration of the most commonly used finished and rough bolts with hexagonal heads, studs, and slotted-head screws, as given on about 50 out of the 120 standard sheets, will show that the range of different diameters covers about 300 Whitworth bolts and screws and about 400 metric ones. If in addition to the diameters the standard lengths of these bolts and screws are taken into account, there is a total of 4200 Whitworth and 5400 metric bolts and screws. Multiplication of these numbers by the quantity of each kind of bolt and screw to be kept in stock, or by the daily capacity of a machine, gives an idea of the tremendous burden laid on German industry by the coexistence of two thread systems, not to speak of its influence on the question of tools and gages.

[1] Translated by John Gaillard, Mechanical Engineer, American Standards Association, New York, N. Y. Mem. A.S.M.E.

TRANSLATOR'S NOTE. This article, published here in abbreviated form, was originally written by Mr. Gramenz in the spring of 1926 as a contribution to a commemorative book issued by Bauer & Schaurte, Rhenish Bolt and Nut Works, Inc., of Neuss on the Rhine, Germany, on the occasion of the fiftieth anniversary of that firm. A few changes from the original text have now been made by the author which again clearly illustrate that there is a constant shift in the limitations of standardization as referred to in the article. Whereas, for example, the original article stated that the prospect of standardizing the hardness of grinding wheels did not seem to be very bright, this statement has now been omitted as experiments carried out since 1926 have shown that it seems quite possible to establish standards for their hardness and grain size.

Further examples of cases where standardization has found its limitations in the requirements of existing tradition are given by the metric thread for diameters below 6 mm., for which the pitches and diameters of the Loewenherz thread had to be adopted; the fine thread with 10 threads to the inch, used in the locomotive industry for valves, etc.; the thread for non-interchangeable safety fuses (DIN VDE 9301) with a diameter of $^3/_{16}$ in. and 24 threads per inch; and finally the screw threads of the fire-hose couplings of the German federal railways.

A case where insurmountable difficulties seem to prevent standardization, and more particularly international standardization, is that of the gage for railroad tracks. Nearly all European countries have adopted a gage of 1435 mm. Russia, however, has a gage of 1524 mm., and Spain one of 1740 mm. Notwithstanding the complications and the difficulties caused at the frontier stations by this divergency in gage, the countries in question will practically be prevented from considering a change over to the standard of the other countries because of the high cost involved in making it and the incalculable disturbances in domestic traffic.

Remarkable also is the series of machine tapers laid down in DIN 228, the intermediate part of which consists of the Morse tapers 0 to 6, while the smaller and larger sizes are metric tapers. The difference in angle between Morse and metric tapers, and between the several Morse tapers themselves, had to be adopted for practical reasons, namely, the wide use of Morse tapers in existing tools and machine tools, and with a view to export. However, the minute differences in taper can hardly be maintained in performing the grinding operation. The difficulty of manufacturing the tapers is thus considerably increased, as it is necessary in each individual case to adjust the grinding machine to the taper in question, whereas the exclusive standardization of a metric taper with a ratio 1:20 would permit setting the machine to this taper once for all, a condition which would result in a much smoother production.

A case of fundamental importance is that of the standardization of systems of metal fits. Although it may perhaps be held that, all factors being considered, the basic shaft system has a certain advantage from the viewpoint of design and the cost of machining—an advantage which actually also exists in the mass production of certain parts in limited quantities—the basic hole system when applied to manufacture in varying quantities and a certain diversity of products, presents the advantage of requiring a smaller and more easily controlled set of tools, an advantage which basically influences the initial cost of tools and gages. However, most factories are dealing with production in different quantities and with a certain variation, if not always in the nature of the products, then at least in the number of machines of the same class, and these conditions cause the basic hole system to be widely used, although the basic shaft system would be, with almost no exception, the most advantageous one in case the more desirable mass-production methods were applied. Thus, in order to reckon with existing conditions, it was necessary to establish two systems of fits, whereas the purpose of standardization should have been, and in fact was, to standardize a single system of metal fits.

The coexistence of these two systems of fits no doubt leads to difficulties in the cooperation between different manufacturers, as for example, in the case of the ends of electric-motor shafts.

Another case where clinging to conventional practice has handicapped standardization is the standardization of eyebolts. The considerations with regard to the personal responsibility connected with the suspension of heavy loads which had been handed down by tradition on the basis of experience, made it impossible to arrive at a uniform standard on this subject.

INDIVIDUALITY

Standardization must not subdue the expression of individuality by submerging everything in a general uniformity. It should, however, start at the point where individual efforts are not justified by the results to be achieved and only cause scattering of efforts. Standardization must rather liberate these forces and resources for the solution of really urgent problems. Emphasis on personal individuality demonstrates itself often in an unjustifiable manner with regard to objects subject to taste and fashion. Large groups must first learn to distinguish between essential and non-essential things, and to foster standardization in cases where its existence is justified and where it is able to contribute to a reduction in the cost of living.

In a very acute form, individualism shows itself in competition. Every one tries to create something special to attract customers and—especially in the field of replacement parts—to keep them. This situation may be worth while striving for from the standpoint of the individual manufacturer, but it is uneconomical from a general point of view. It is being more and more realized that common interests must be placed above the interests of the individual, and that raising the general level will also ultimately benefit the interest of the individual, as standardization reduces the cost of the production of goods and makes the latter available to the largest possible number.

There was some justification in the fact that standardization in the building trades at first took place under the influence of regional individualism, an architectural style dependent on local conditions, and under adaptation to the prevailing weather conditions in each case, but even here standardization gradually triumphed over old tradition.

The standardization of the shape of a plowshare met with considerably greater difficulties due to individualistic considerations. The form of a plowshare depends on the greatly varying consistency of the soil, the method of plowing, the force used for propelling the plow, and, finally, on the century-old habits of a type of man holding very tenaciously to convention. Moreover, as it is extremely difficult to reach the different groups of users of this kind of equipment, it seems that for the present no standard can successfully be established. However, a standard dealing with the dimensions governing the connection of the share to the plow is in course of development.

A field requiring careful consideration of existing conditions is that of methods of packing. In addition to questions of personal wishes, taste, fashion, and competition which must be taken into account, the manner of shipping, the method of selling in the retail trade, and the possibilities and particularities of transportation tend to slow down the efforts toward unification.

TECHNICAL PROGRESS

All objects which are still in a period of active development should naturally be exempt from standardization. On the other hand, it cannot be said with certainty of any object that its development has come to an end. Therefore a standard must adapt itself to the technical progress in methods of manufacture and application. Perhaps this applies more strongly to standards for materials than to dimensional standards. It may be emphasized here again that in principle, standardization work should be started only with regard to objects whose development has at least arrived at a certain point of temporary stability. Otherwise there is the danger that standardization will favor the repetition of errors. Such danger will prevail especially when unripe standards are incorporated into rules issued by public authorities, as such rules often cannot be so easily changed.

A question of fundamental importance is whether the *material* of standardized commercial parts shall be specified. Of course, the standardization of commercial parts has but a partial value

when it deals with dimensions exclusively and not with properties of materials. A taper key or pin of too soft a steel has no value, and, in the same way, a screw is useless when made of unsuitable material. Now it can be safely assumed that a conscientious production manager, desirous of keeping his customers, will always try to use that material for his products which insures their practical usefulness. There are, however, different views as to what constitutes practical suitability. A spline for the highly stressed parts of an automotive vehicle requires a better grade of material than, for example, a spline intended for a hand-driven crane winch. As evidently the quality of material also influences the price of a standard part, the consumer has a certain interest in the specification of the material. In order to make it easier for the consumer to specify the material and at the same time to protect the producer from unreasonable arbitrariness on the part of the consumer, it may therefore be useful to supplement the dimensional standard for commercial parts by a mention of the material, which may sometimes be given in two or more grades of quality.

The rigid specification of a particular material may, however, cause difficulties for the producer. Under certain conditions it will be more economical for him, and moreover will simplify his stock keeping, to make, for example, taper pins of a single high-grade material rather than from two materials of different quality. It is also desirable to provide a certain flexibility with regard to the utilization of parts left over and of scrap.

Furthermore the manufacturing process has an essential influence on the selection of the material. With a view to the use of forging machines and drop-forging dies, it may be desirable to start out with a material of low tensile strength and by special treatment impart to this material, after it has passed through the different machining operations, the high-grade properties required for the use of the final product. The manufacturing processes being largely the problem of the producer and often still subject to extended technical development, specification of the material of standard parts can be objectionable. Also, there are parts for which such specification has only a limited value. In the case of a bolt, for example, the head may have a tendency to tear off when the material is spoiled during the manufacturing process, perhaps because the head was upset after being insufficiently heated or because of defective upsetting.

The consumer's first interest is in whether the final product as purchased by him is suitable to withstand the stresses to which it will be subjected in use. His interest would be much better safeguarded in such cases—further examples in addition to bolts are nuts, wrenches, etc.—by the establishment of certain test specifications for the final product than by the specification of the material of which the parts should be made.

Competition

Standardization must leave room for sound competition, a driving force of progress. It must also leave room for the technical achievements of the individual in cases where these have a chance of success. An example of this may be found in the standardization of tools. Whereas in the case of bolts and nuts the final product must possess certain material properties, the latter also being required in the interest of general safety, the consumer of tools has to consider exclusively their suitability for service, judged on the basis of cutting speed, quality of finish, and life. The effects of these properties depend to such extent on special conditions that the establishment of simple and sound methods of test is extremely difficult. Judgment consequently depends much on the personal views of individuals, and the establishment of standards for such judgment is very difficult, if not impossible. On the other hand, the establishment of such standards is in general not necessary, as after some experience the user of tools will find out sooner than the user of any other standard product which tool manufacturer gives him good service.

Cutting speed, quality of workmanship, and life of tools depend on the selection of the material, the temper, the cutting angle, and the shape of the grooves for removal of the chips. Different materials require different cutting angles for their machining. All these factors are subject to a large extent to personal experience. The standardization of tools therefore concerns only the specification of the principal dimensions, including tolerances, but not, however, of the material, cutting angle, number of teeth, tooth shape, and number and shape of the flutes.

The requirements of dimensional precision form an important chapter in standardization. Specification of such precision is in many cases essential as a guarantee for the correct functioning of a standard part. At the same time, however, it tends, within certain limits, to increase the cost of production and therefore should be restricted to the minimum required and should stay within boundaries compatible with economical production. Increased mass production often results in greater dimensional precision because of the use of special equipment and gages. The purchase of such equipment must be justified by a sufficient volume of mass production, or the orders must be distributed between different works in such a way as to guarantee that the production within each of these can be based on a sufficient number of units. Specifications of quality applying evidently to special cases only must not be expanded to apply in general to commercial products. They have their effect also on the price of products of the same class which do not require so high a precision, as under certain conditions regular mass production may be disturbed by the establishment of two grades of product.

Technical Inability

In standardization work there are also cases, as mentioned before, where technical inability limits the desires and efforts of those interested, for example, with regard to dimensional precision. Due to the imperfection of methods of production and measurement, it is impossible in practice to make parts of exactly the same size, even if but a single dimension is concerned. The precision of manufacture depends on the nature of the production methods, which must be chosen on the basis of considerations of economy of manufacture. Such precision may be a question of a few millimeters in the rolling of metal sheets and sections, or of a few ten-thousandths of a millimeter in making gage blocks. The accuracy of measurement has been refined to a few hundred-thousandths of a millimeter in the light-wave interference comparator; but the accuracy of measuring tools used in the workshop is considerably below this, and is more or less influenced by well-known causes of error.

Relative inaccuracy of methods of manufacture and measurement does not by itself constitute a limitation of standardization. The function of standardization is rather to establish dimensional precision in such a way that it harmonizes with the production method to be preferred in each specific case on the basis of economy of manufacture, at the same time taking into consideration the relative error inherent in the methods and devices used for measurement. Difficulties arise only in those cases where assembly of the component parts and the requirements for this assembly which are dictated by the function of the product in practical use, lead to a demand for dimensional precision so high that it cannot be obtained in practice.

An example of this is found in the assembly of ball bearings with other parts. The precision to be observed in the manufacture of ball bearings is already very close to the limit of what can be attained at the present time. It satisfies certain require-

ments of interchangeable manufacture. However, if special conditions as to uniformity of the fits are established, the parts mating with the bearings must be finished with extreme accuracy, provided absolute interchangeability is to be attained. The difficulties caused by the technical inability to increase the dimensional accuracy of ball bearings and their mating parts above a certain point made it necessary for a long time to refrain from the establishment of definite and universally recognized standards for the assembly of ball bearings with other parts.

Such difficulties arise, for example, in the establishment of tolerances for machine tapers. Methods of manufacture and measurement require the maintenance of tolerances on the gages for machine tapers which are about the smallest ones practicable. The tapers on small tools and machine-tool spindles of course deviate to a certain degree from these gages. Experiments have been made to determine whether the accuracy which can be obtained in the manner referred to insures that there will be sufficient adherence between tool and spindle, or whether there exists here another limitation of standardization. In the latter case there would remain the possibility of establishing the manufacturing limits of machine tapers with an accuracy satisfactory for their working conditions, by means of other methods of measurement.

Another case where standardization was subject to limitations arose in the establishment of tap-drill sizes as given on the German standard sheet DIN 336. In view of the fact that different factors influence the drilling process so as to cause oversize holes, it was necessary to mention on the standard sheet that the standard tap-drill sizes should not be used for internal threads, whose minor diameter must lie within the manufacturing limits laid down by the standard for screw-thread tolerances.

The foregoing considerations indicate that limitations of dimensional standardization caused by technical inability occur in cases where technical requirements would call for the specification of a dimensional accuracy which cannot be realized with present methods of manufacture and measurement. Such cases are rare. In general, however, there should not exist any limitation of dimensional standardization by technical inability, as it is humanly possible to agree on a definite value for a certain dimension and to specify a manufacturing tolerance on this value which lies within the reach of our present technique.

In principle, the standardization of engineering materials presents the same problem, this being simply to establish standards which can be maintained in practice; in other words, to specify chemical and physical properties with such limiting values as can practically be maintained. The manufacture of engineering materials depends to a great extent on the raw materials available—that is, in the case of steel, on the properties of the ores to be treated and on the kind of coal used. Now these two materials vary even within the boundaries of a country of the size of Germany. Apart from these variations in the raw materials, the manufacture of engineering materials is subject to a number of influences which, up to the present time, have been but little investigated. The fundamental differences in the nature of the manufacturing processes and the possibility of making tests during production, call for requirements in establishing standards for engineering materials which are different from those governing the establishment of dimensional standards and which are subject to influences which cannot yet be controlled rather than determined by human will. No doubt the uniformity of the products can be improved to a certain extent by producing in larger quantities. For this reason the standardization of engineering materials must, even more than in the case of dimensional standardization, be limited to the specification of a few items satisfying average requirements.

Special difficulties arise in establishing the tensile strength and elongation of drawn steel, as for various reasons the influences governing the elastic properties during the drawing process cannot be entirely controlled.

The standardization of grinding wheels also has certain limitations, in so far as their properties are concerned, due to technical inability. Formerly it was difficult to establish a uniform designation of the grain size and of the hardness of the wheels because of a lack of suitable methods of test. At present the standardization of grain sizes seems to be possible through the standardization of sieves and test methods. The prospect of standardizing the hardness of the wheels, however, does not yet seem to be very bright.

CONCLUSION

The ever-increasing need of standardization is a result of the tendency toward a better-planned system of producing goods. Standardization must aid in reducing the cost of production and transportation of goods. A standard should therefore in the first place foster economy. Otherwise it either hampers economic progress or remains a "paper standard." This fundamental requirement with which a standard must comply is sufficient to indicate the limitations of standardization.

Standardization cannot disregard tradition without serious loss through the wiping out of tremendous investments. Also, standardization cannot simply abolish certain existing forms in the economic structure; it can only influence the functions and effects of the latter. Nor can standardization change technical considerations overnight; it must let experience ripen in the course of time. Personal views based on experience and local conditions cannot be forced. The road of technical progress must be left free. Standardization must not eliminate sound competition, but only do away with unjustifiable and uneconomical variety. Technical inability makes itself felt in matters of standardization, with regard to the limits of dimensional accuracy and the production of engineering materials.

The foregoing discussion by no means deals exhaustively with the limitations of standardization. It shows, however, that standardization is subject to so many natural limitations that there is obviously no foundation for any fear that it can be carried so far that it will permanently damage our economic structure.

An Air-Cooled Diesel Airplane Engine

POSSIBILITIES and advantages of heavy-oil engines for aircraft use are presented in an article by L. M. Woolson, of the Packard Motor Car Co., in the February number of the *S.A.E. Journal*. According to Mr. Woolson, the engine experimented with by his company weighs less than 3 lb. per hp. developed, is capable of withstanding cylinder pressures in excess of 1200 lb. per sq. in., and operates at compression ratios as high as 18 to 1 and at engine speeds from 1700 to 2000 r.p.m.

The greatest advantage claimed for this type of engine as compared with the gasoline engines now used universally for airplanes is its reliability. If one cylinder fails for any reason to function, the others continue, and the only effect is a reduction of power. For these reasons Mr. Woolson believes that the oil engine is so reliable that when such engines become commercially available in large sizes it will not be necessary to use more than one engine in large airplanes.

The second most important advantage is that virtually no fire risk exists with the Diesel engine, and consequently the dangers to passengers and pilot in case of a crash are greatly diminished.

A third great advantage is that the specific fuel consumption is about 20 per cent less than with the gasoline engine, and the fuel cost is reduced about 70 per cent.

Worm Gears—A Study and Review of Existing Data

Progress Report No. 2 of the A.S.M.E. Special Research Committee on Worm Gears[1]

THE preliminary report of this research committee was presented before the Society in December, 1926, under the title of "Worm-Wheel Contact." This paper proposed studying worm drives as a special case of thrust bearings, and gave an analysis of the worm contact conditions.

The first progress report of the committee is a geometrical analysis of the contact conditions on a series of worms under different meshing conditions and consists primarily of 120 tracings showing the projection of the contact lines on the end section and plan view of the worm, together with sections of the worm thread and the profiles of a 30-tooth worm gear at varying distances from the center line of the worm. This report, because of the expense of the large number of blueprints, was distributed only to the members of the research committee, and was made to clarify the subject of worm contact before attempting to study any test data. The report may be obtained at cost from A.S.M.E. headquarters by any one interested.

It seemed advisable to start the active work of this committee by a study and review of existing data. To this end a circular letter was sent out about a year ago requesting any available information, either of actual tests or service data on actual installations. A gratifying response has been made to this appeal. Further information of this nature will be welcomed at any time. This progress report deals with the first of this material which has been received.

TEST DATA ON WORM DRIVES

The following analyses of test data on worm drives have been made as though these drives were simple thrust bearings. The power losses in foot-pounds per minute have been divided by the circumferential velocity of the worm at its pitch diameter (called rubbing speed for simplicity), which gives the frictional resistance in terms of pounds at a radius equal to the pitch radius. The contact lines for each half-pitch advance of the worms have been established and are shown on the accompanying diagrams.

WORM DRIVE AW-1

Single-thread worm of hardened steel
2.022 in. pitch diameter
2.817 in. outside diameter
1.102 in. root diameter
27° half included angle of thread milling cutter
11° 8′ helix angle at pitch diameter
1.250 in. circular pitch
1.250 in. lead of worm
8.173 in. center distance
36 teeth in bronze worm gear

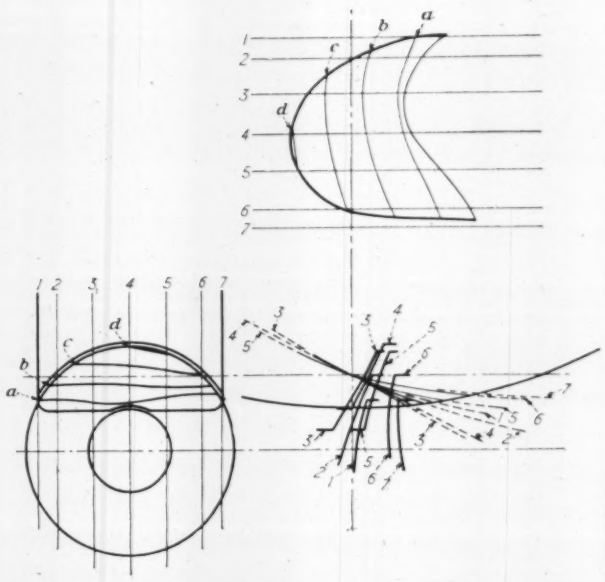


FIG. 1 SINGLE-THREAD WORM DRIVE AW-1. CONTACT LINES FOR EACH HALF-PITCH ADVANCE

TABLE 1 TEST DATA OF WORM DRIVE AW-1

(Brake arm, 3 ft.; dynamometer arm, 21 in.; rubbing speeds at pitch line of worm; lubricant, 600W cylinder oil)

Brake scale, lb.	Dynamometer scale, lb.	Temperature, deg. fahr.	Power loss, ft-lb. per min.	Tooth load, lb.	Frictional resistance, lb.	Coefficient of friction
645 R.p.m. of Worm.	Rubbing Speed, 341 Ft. per Min. 77 Deg. Fahr.					Room temp.,
50	3.3	151	6528	251	19.1	0.0761
100	6.5	150	8798	503	25.8	0.0513
200	11.5	151	14049	1005	41.1	0.0409
300	17.3	153	21428	1508	62.8	0.0416
400	23.6	156	31645	2011	92.7	0.0461
500	29.9	160	43281	2513	126.8	0.0505
922 R.p.m. of Worm.	Rubbing Speed, 488 Ft. per Min. 77 Deg. Fahr.					Room Temp.,
50	3.3	160	9331	251	19.1	0.0761
100	5.9	158	11562	503	23.7	0.0471
200	11.3	158	18053	1005	37.0	0.0368
300	16.7	159	24543	1508	50.3	0.0333
400	22.2	161	32048	2011	65.7	0.0327
500	28.2	164	44624	2513	87.4	0.0348
1232 R.p.m. of Worm.	Rubbing Speed, 652 Ft. per Min. 77 Deg. Fahr.					Room Temp.,
50	3.4	159	13823	251	21.1	0.0844
100	6.1	174	18160	503	27.8	0.0553
200	11.3	174	24124	1005	37.0	0.0368
300	16.7	174	32796	1508	50.3	0.0333
400	22.0	176	40115	2011	61.5	0.0306
500	27.5	178	50144	2513	76.9	0.0306
1550 R.p.m. of Worm.	Rubbing Speed, 821 Ft. per Min. 77 Deg. Fahr.					Room Temp.,
100	6.2	178	24554	503	29.9	0.0594
200	11.4	178	32058	1005	39.1	0.0389
300	16.6	178	39562	1508	48.2	0.0319
400	22.1	173	52181	2011	63.6	0.0316
500	27.6	177	64800	2513	79.0	0.0314

[1] The personnel of the A.S.M.E. Special Research Committee on Worm Gears is as follows:

Earle Buckingham, *Chairman*, Associate Professor, Engineering Standards and Measurement, Massachusetts Institute of Technology, Cambridge, Mass.

George H. Acker, Chief Engineer, Cleveland Worm and Gear Co., Cleveland, Ohio.

Joseph J. Broshek, Commander, U. S. Navy, Fuel Oil Testing Plant, Philadelphia, Pa.

L. Ray Buckendale, Sales Engineer, Timken-Detroit Axle Co., Detroit, Mich.

David L. Lindquist, Chief Engineer, Otis Elevator Co., New York, N. Y.

A. A. Ross, Engineer, Metal Gear Department, General Electric Co., River Works, West Lynn, Mass.

Benjamin F. Waterman, Designer, Brown & Sharpe Manufacturing Co., Providence, R. I.

W. H. Himes, Mechanical Engineer, Westinghouse Electric Co., East Pittsburgh, Pa.

14.324 in. pitch diameter
15.250 in. outside diameter.

The contact lines for each half-pitch advance are shown in the accompanying sketch Fig. 1. The minimum projected length of the contact is about 2.00 in. The test data are given in Table 1.

The values of the frictional resistance in Table 1 have been plotted against the tooth load and also against the rubbing speed in Figs. 2 and 3.

WORM DRIVE AW-2

Double-thread worm of hardened steel
2.380 in. pitch diameter

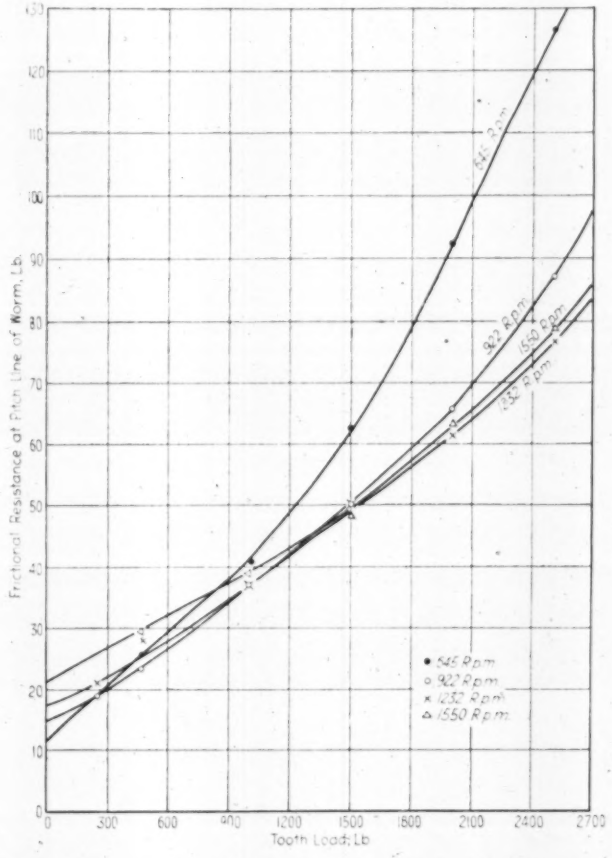


FIG. 2 WORM DRIVE AW-1. FRICTIONAL RESISTANCE PLOTTED AGAINST TOOTH LOAD

3.096 in outside diameter
1.552 in. root diameter
26° half included angle of thread milling cutter
16° 45′ helix angle at pitch diameter
1.125 in. circular pitch
2.250 in. lead of worm
8.173 in. center distance
39 teeth in bronze worm gear
13.966 in. pitch diameter
14.750 in. outside diameter.

The contact lines of this drive are shown in Fig. 4. The minimum projected length of the contact is about $2^1/_8$ in. The test data are given in Table 2.

These values of the frictional resistance have been plotted against the tooth loads in Fig. 5. They appear to be too high in comparison with the data on other worm drives.

When the case was disassembled after these AW-2 tests were completed, the radial ball bearing on the worm shaft was found to be assembled too tightly and turned only with considerable effort. This bearing was replaced for tests AW-1 and AW-3. It is possible that the excessive friction in the tight bearing on test AW-2 masked much of the influence of the change of loads and speeds on this series of tests.

TABLE 2 TEST DATA OF WORM DRIVE AW-2

Brake scale, lb.	Dynamometer scale, lb.	Temperature, deg. fahr.	Power loss, ft-lb. per min.	Tooth load, lb.	Frictional resistance, lb.	Coefficient of friction
LUBRICANT, 600W CYLINDER OIL						
1232 R.p.m. of Worm.		Rubbing Speed, 768 Ft. per Min. 74 Deg. Fahr.				Room Temp.,
420	43.0	74	82556	2165	107.5	0.0496
380	38.8		73274	1959	95.5	0.0487
350	36.0		71055	1805	92.6	0.0513
300	31.0		62840	1547	81.9	0.0529
250	26.4	to	60047	1289	78.2	0.0606
200	21.6		54542	1031	71.1	0.0689
150	16.6		46327	773	60.3	0.0780
100	11.9		42178	516	54.9	0.1064
50	7.2		38029	258	49.5	0.1918
6.25	2.5	118	26437	32	34.4	1.0750
LUBRICANT, 2 PARTS CASTOR OIL + 3 PARTS 600W CYLINDER OIL						
1232 R.p.m. of Worm.		Rubbing Speed, 768 Ft. per Min. 86 Deg. Fahr.				Room Temp.,
450	44.3	169	64447	2320	84.0	0.0362
400	39.6	169	60297	2062	78.5	0.0381
350	34.8	168	54793	1804	71.4	0.0396
300	30.3	166	53354	1547	69.5	0.0449
250	25.9	163.5	53271	1289	69.4	0.0538
200	20.8	162	43701	1031	56.9	0.0552
150	16.5	161	44972	773	58.6	0.0758
100	11.6	158	38112	516	49.6	0.0961
50	6.7	157	31253	258	40.7	0.1578
25	4.6	153	32566	129	42.4	0.3287
1024 R.p.m. of Worm.		Rubbing Speed, 638 Ft. per Min. 86 Deg. Fahr.				Room Temp.
475	46.8	159	56976	2449	89.3	0.0365
400	39.8	158	52370	2062	82.1	0.0398
350	35.2	159	50048	1804	78.4	0.0435
300	30.3	159	44346	1547	69.5	0.0449
200	20.9	158	37449	1031	58.7	0.0569
817 R.p.m. of Worm.		Rubbing Speed, 509 Ft. per Min. 86 Deg. Fahr.				Room Temp.
475	47.1	158	48158	2449	94.6	0.0386
400	39.7	159	40885	2062	80.3	0.0389
300	30.4	158	36281	1547	71.3	0.0461
200	20.8	157	28980	1031	56.9	0.0552
1770 R.p.m. of Worm.		Rubbing Speed, 1103 Ft. per Min. 86 Deg. Fahr.				Room Temp.,
350	34.9	153	80667	1804	73.1	0.0405
300	30.3	154	76653	1547	69.5	0.0449
250	25.7	154	72639	1289	65.8	0.0539
200	21.0	153	66678	1031	60.5	0.0587
150	16.3	152	60717	773	55.1	0.0713

WORM DRIVE AW-3

Six-thread worm of hardened steel
3.077 in. pitch diameter
3.759 in. outside diameter
2.287 in. root diameter
27° half included angle of thread milling cutter
41° 45′ helix angle at pitch diameter
1.4375 in. circular pitch
8.625 in. lead of worm
8.173 in. center distance
29 teeth in bronze gear
13.269 in. pitch diameter
14.250 in. outside diameter.

The contact lines of this drive are shown in Fig. 6. The minimum projected length of the contact line is about $2^1/_4$ in. The test data are given in Table 3.

These values of the frictional resistance have been plotted against the tooth loads in Fig. 7. The worm gear in test AW-3 did not have full bearing. The bearing only extended about one-third of the distance across the face of the gear tooth on the left-hand side of the center as shown in Fig. 6, and did not extend above the pitch line of the gear tooth.

TABLE 3 TEST DATA OF WORM DRIVE AW-3

Brake scale, lb.	Dynamometer scale, lb.	Temperature, deg. fahr.	Power loss, ft-lb. per min.	Tooth load, lb.	Frictional resistance, lb.	Coefficient of friction
LUBRICANT, 600W CYLINDER OIL						
1232 R.p.m. of Worm. Rubbing Speed, 992 Ft. per Min.						
25	10.8	159	26245	136	26.4	0.1941
35	14.6	160	29695	190	29.9	0.1574
45	17.7	160	23659	244	23.8	0.0975
55	21.8	162	31176	298	31.4	0.1054
65	24.8	163	23785	353	24.0	0.0680
75	28.9	163	31301	407	31.5	0.0774
85	32.6	165	33397	461	33.7	0.0731
95	36.1	166	32782	515	33.0	0.0641
105	39.9	167	36233	570	36.5	0.0640
115	43.8	168	41040	624	41.4	0.0663
125	47.5	170	43134	678	43.5	0.0642
135	51.0	171	42519	733	42.8	0.0584
922 R.p.m. of Worm. Rubbing Speed, 743 Ft. per Min.						
25	10.4	169	15584	136	21.0	0.1544
35	14.1	169	17152	190	23.1	0.1216
45	17.7	169	17706	244	23.8	0.0975
55	21.3	169	18261	298	24.6	0.0825
65	25.0	169	19828	353	26.7	0.0756
75	28.6	169	20382	407	27.4	0.0673
85	32.2	170	20936	461	28.2	0.0612
95	36.1	170	24533	515	33.0	0.0641
105	39.5	170	23059	570	31.0	0.0544
125	47.2	172	29238	678	39.4	0.0581
145	54.3	173	29332	787	39.5	0.0502
165	61.9	174	34497	895	46.4	0.0518
185	69.2	175	36619	1004	49.3	0.0491
205	76.7	176	40769	1112	54.9	0.0493
LUBRICANT, 2 PARTS CASTOR OIL + 3 PARTS 600W CYLINDER OIL						
1232 R.p.m. of Worm. Rubbing Speed, 992 Ft. per Min.						
25	10.3	160	19469	136	19.6	0.1441
35	14.0	160	21564	190	21.7	0.1142
45	17.7	160	23659	244	23.8	0.0975
55	21.0	161	20334	298	20.5	0.0688
65	24.8	162	23785	353	24.0	0.0680
75	28.6	162	27235	407	27.4	0.0673
85	32.2	163	27976	461	28.2	0.0612
95	35.8	164	28717	515	28.9	0.0561
105	38.9	164	22681	570	22.9	0.0402
115	42.6	165	24771	624	25.0	0.0401
125	46.2	166	25516	678	25.7	0.0379
135	50.0	167	28967	733	29.2	0.0398
145	53.8	168	32418	787	32.7	0.0415
155	57.4	169	33159	841	33.4	0.0397
165	60.3	170	32544	895	32.8	0.0366
922 R.p.m. of Worm. Rubbing Speed, 743 Ft. per Min.						
25	9.9	169	10513	136	14.2	0.1044
35	13.5	168	11067	190	14.9	0.0784
45	17.2	168	12635	244	17.0	0.0697
65	24.4	168	14743	353	18.5	0.0524
85	31.8	168	16880	461	22.7	0.0492
105	39.1	169	18982	570	25.6	0.0449
125	46.4	169	21125	678	28.4	0.0419
145	53.4	170	20204	787	27.2	0.0346
165	60.6	170	21312	895	28.7	0.0321
185	67.9	172	23435	1005	31.6	0.0314
205	74.9	172	22514	1112	30.3	0.0272
215	78.8	172	26111	1167	35.2	0.0302

For purposes of comparison, in Fig. 8 the frictional resistance has been plotted against the tooth load on the following tests, which should be commensurate in some degree. The lubricant in all these tests was 600W cylinder oil.

AW-1 at 1550 r.p.m. Rubbing speed, 821 ft. per min.
AW-2 at 1232 r.p.m. Rubbing speed, 768 ft. per min.
AW-3 at 922 r.p.m. Rubbing speed, 743 ft. per min.

The values of the frictional resistance on run AW-2 have all been reduced by 22 lb. to bring the curves together. Some such correction of an unknown amount should be made to correct for the tight bearing used on this run.

WORM DRIVE AW-4

Four-thread worm of hardened steel
4.104 in. pitch diameter
5.812 in. outside diameter
3.212 in. root diameter
30° half included angle of thread milling cutter
32° 29′ helix angle at pitch diameter
2.250 in. circular pitch
9.000 in. lead of worm
12.437 in. center distance
29 teeth in bronze worm gear
20.770 in. pitch diameter.

The minimum projected length of the contact line is about $5^1/_2$ in.

Test Data, AW-4. This worm drive is in service driving a conveyor with a normal load of 20 hp. at a speed of 1150 r.p.m. of worm, service 24 hours a day, mostly at full load. After about two years' service this drive was overhauled and the teeth of the gear were found to be pitted on the entering side. The gear teeth also showed a slight polish at the center of the face, with untouched tool marks visible elsewhere. These worn portions are indicated on the diagram of the contact lines, Fig. 9. This drive is still giving satisfactory service.

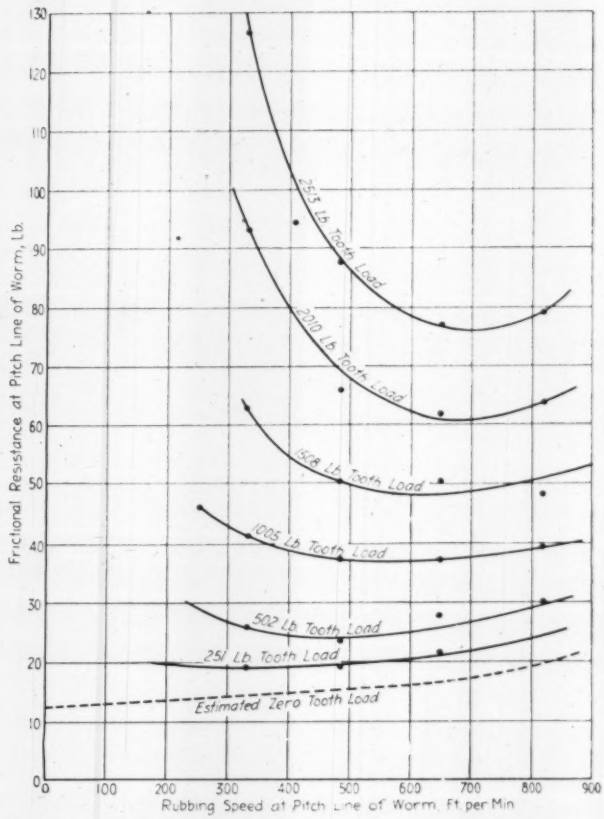


FIG. 3 WORM DRIVE AW-1. FRICTIONAL RESISTANCE PLOTTED AGAINST RUBBING SPEED

The polish at the center of the gear teeth was probably caused by the worm contact during the unloaded operation of the drive. Under load, deflection of the worm and the side deflection of the gear would tend to throw the contact toward the entering side where pitting took place. Probably the surface of the gear teeth failed here until sufficient contact was made to carry the load, after which further failure ceased. Using a similar analysis of the load-carrying ability for this worm drive, which will be taken up in more detail later, to that used for spur gears, a contact line of from $^1/_2$ in. length to $^3/_4$ in. would probably be sufficient to carry this load. This agrees very well with the conditions found, and this pitting probably occurred soon after the original installation of this drive.

WORM DRIVE AW-5

Nine-thread worm of hardened steel
3.015 in. pitch diameter
3.441 in. outside diameter
2.524 in. root diameter
14½° half included angle of thread milling cutter
38° 16′ helix angle at pitch diameter of worm

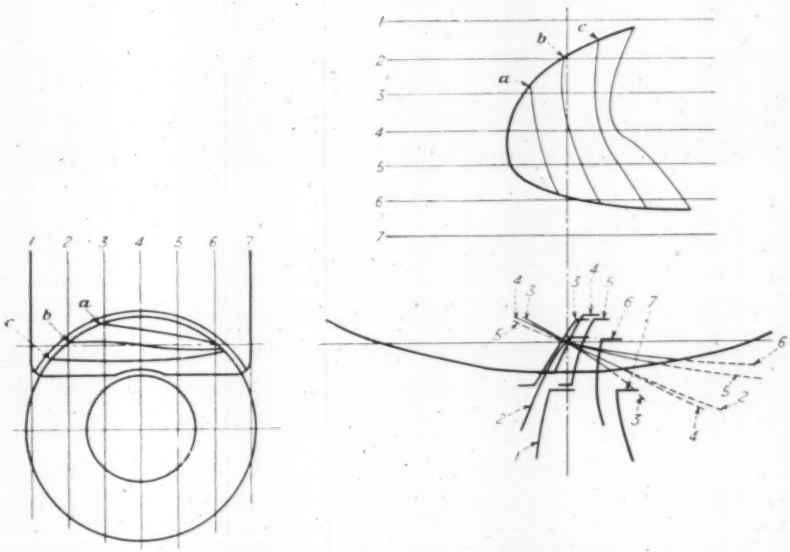


FIG. 4 DOUBLE-THREAD WORM DRIVE AW-2. CONTACT LINES FOR EACH HALF-PITCH ADVANCE

0.8302 in. circular pitch
7.4719 in. lead of worm
6.7927 in. center distance
40 teeth in bronze worm gear
10.5704 in. pitch diameter
10.9964 in. throat diameter

The minimum projected length of contact is about 2¼ in. Fig. 10 shows the contact lines at each half-pitch advance as before.

These tests were reported in a paper on "Efficiency of Gear Drives," presented before the A.S.M.E. in June, 1918, by Messrs. Allen and Roys, and the data are given in Table 4. The lubricant used was a heavy oil sold by the Texas Company under the name of "Thuban Oil."

TABLE 4 TEST DATA ON WORM DRIVE AW-5

R.p.m. of worm	Output, hp.	Hp. loss	Rubbing speed, ft. per min.	Tooth load, lb.	Frictional resistance	Coefficient of friction
		Tests at 80 Deg. Fahr.				
1109	20.030	1.930	875	957	72.8	0.0761
1137	16.395	1.635	897	764	60.1	0.0787
1156	12.475	1.435	912	572	51.9	0.0907
1175	8.413	1.105	927	379	39.3	0.1037
1193	4.215	0.835	942	187	29.3	0.1567
1200	1.953	0.807	947	86	28.1	0.3267
		Tests at 150 Deg. Fahr.				
1109	19.990	2.110	875	955	79.5	0.0832
1137	16.394	1.706	897	764	62.7	0.0821
1156	12.480	1.270	912	572	45.9	0.0802
1175	8.456	0.964	927	381	34.3	0.0900
1193	4.255	0.645	942	189	22.6	0.1196
1200	2.096	0.554	947	93	19.3	0.2075

The values of the frictional resistance have been plotted against the tooth loads in Fig. 11.

All of these test curves show considerable resemblance to each other. There are so many varying factors involved that it is difficult to compare one series of tests with another until we can evolve some rational basis of comparison. We shall therefore consider some of the major factors which must be correlated in some way.

VARYING FACTORS ON WORM DRIVES

We shall first attempt to list some of the major factors which affect the power losses on worm drives and which also determine the maximum load and speed conditions under which these drives will operate satisfactorily. As the breakage of teeth is seldom encountered, we shall omit from this preliminary attempt at analysis the factor of tooth strength. We then have the following indications of distress which are apparent when the drive is operated beyond its capacity:

(1) Pitting of tooth surfaces
(2) Abrasion and rapid wear of tooth surfaces
(3) Excessive temperature of drive.

Considering these conditions in more detail, we have the following major influences involved:

(1) PITTING OF TOOTH SURFACES

The pitting of the tooth surfaces is the result of compressive fatigue of the materials and is dependent upon

(1-a) The physical properties of the material
(1-b) The size, form, and nature of contact between the worm and gear

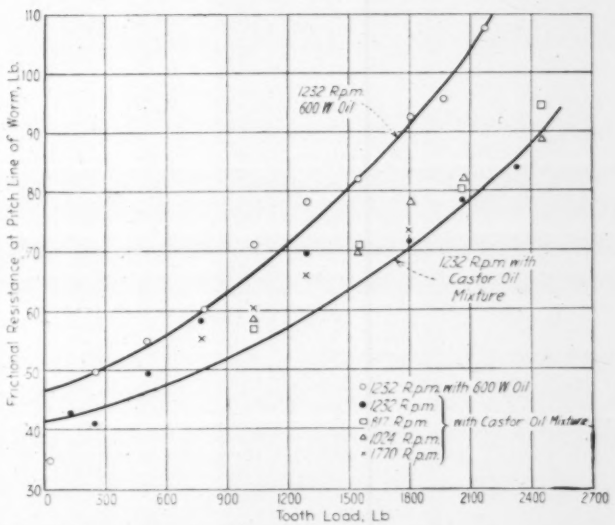

Frictional Resistance at Pitch Line of Worm, Lb.
Tooth Load, Lb
1232 R.p.m. 600 W Oil
1232 R.p.m. with Castor Oil Mixture
1232 R.p.m. with 600 W Oil
1232 R.p.m.
817 R.p.m.
1024 R.p.m.
1720 R.p.m.
with Castor Oil Mixture

FIG. 5 WORM DRIVE AW-2. FRICTIONAL RESISTANCE PLOTTED AGAINST TOOTH LOAD

(1-c) The accuracy of the worm and gear and the accuracy of their alignment
(1-d) The intensity of the applied load
(1-e) The velocity of the engagement
(1-f) The nature of the service (steady loads, intermittent loads, shock loads, etc.).

(2) ABRASION OF TOOTH SURFACES

The abrasion of the tooth surfaces is a result of the failure of the lubricant to keep the rubbing surfaces from making me-

tallic contact. The ability of the lubricant to function properly depends upon

(2-a) The nature of the contact between the worm and gear
(2-b) The characteristics of the lubricant
(2-c) The velocity of the engagement
(2-d) The intensity of the load
(2-e) The method of lubrication
(2-f) The operating temperature of the drive.

(3) TEMPERATURE OF DRIVE

The temperature of the drive depends upon

(3-a) The amount of the power loss
(3-b) The area of the exposed surface of the gear case
(3-c) The room temperature and the location of the case in respect to the circulation of air about it.

As most of the data thus far considered relate to the power losses, we shall first consider item (3-a) in more detail.

(3-a) *The Amount of the Power Loss.* The major factors that affect the power losses of a worm drive are

(3-a-1) The churning of the oil in the case
(3-a-2) The bearing losses
(3-a-3) The worm contact losses.

The totals of all these three sources of power loss are included in the preceding test data and have been converted into the equivalent torque load at the pitch line of the worm. All of these losses have also been included in the determination of the coefficient of friction given in the tables as such a torque load, with the result that in one case this coefficient is greater than unity. We shall now consider the foregoing factors in a little more detail.

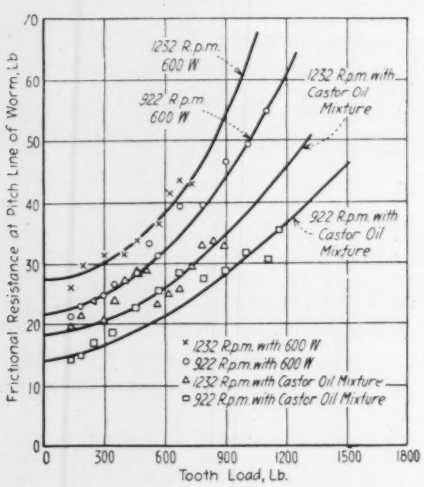

Frictional Resistance at Pitch Line of Worm, Lb
Tooth Load, Lb.
1232 R.p.m. 600 W
922 R.p.m. 600 W
1232 R.p.m. with Castor Oil Mixture
922 R.p.m. with Castor Oil Mixture
× 1232 R.p.m. with 600 W
○ 922 R.p.m. with 600 W
△ 1232 R.p.m. with Castor Oil Mixture
□ 922 R.p.m. with Castor Oil Mixture

FIG. 7 WORM DRIVE AW-3. FRICTIONAL RESISTANCE PLOTTED AGAINST TOOTH LOAD

(3-a-1) *Churning of Oil in Case.* Tests made of the churning losses in an automobile spur-gear transmission indicated that these losses are primarily affected by the viscosity of the lubricant, the velocity of the gears, and the depth of the oil in the case. These tests also indicated that the torque load is nearly constant at all speeds with the same lubricant at the same level and temperature. Also that a change in oil level had a greater influence on this load than a change in viscosity. It is possible that these same conditions would also hold substantially true for worm drives.

The power losses caused by all of the factors involved in the churning of the oil in the case can best be determined by running the drive without load until the temperature remains constant. If possible, torque-load readings should be taken, which can be

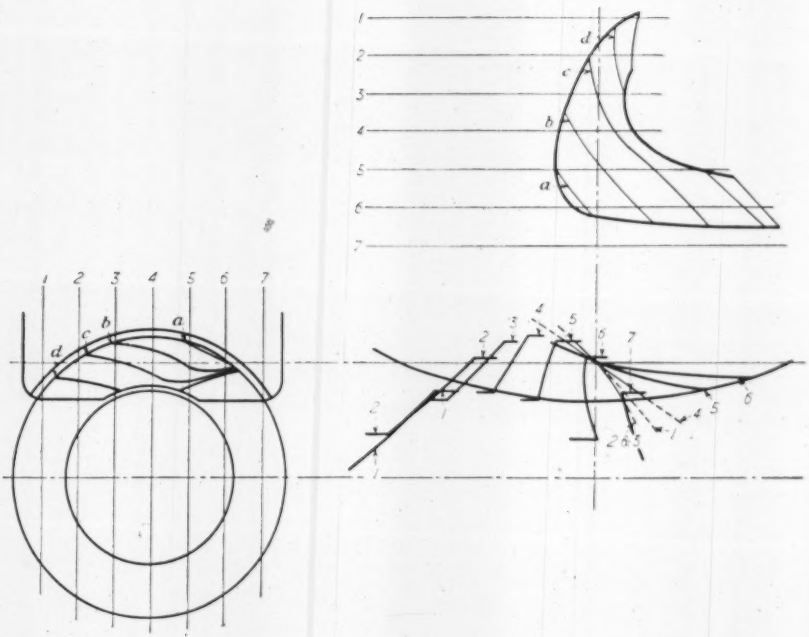


FIG. 6 SIX-THREAD WORM DRIVE AW-3. CONTACT LINES FOR EACH HALF-PITCH ADVANCE

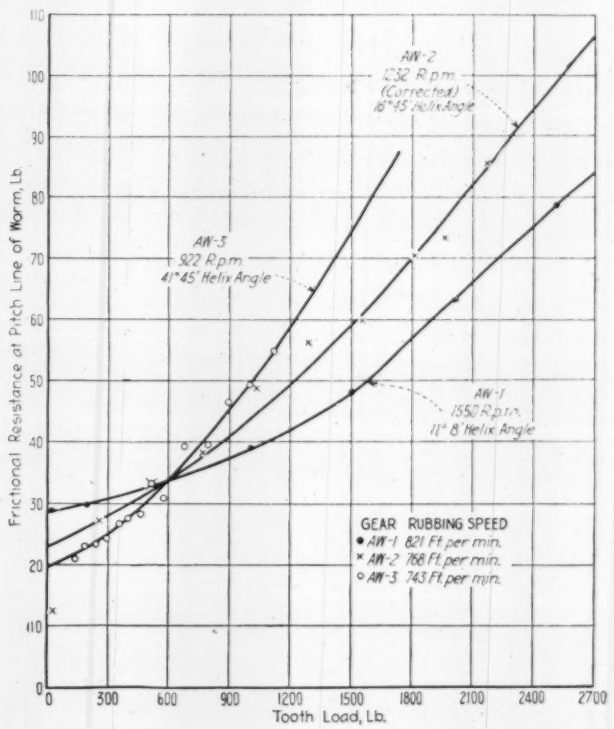

Frictional Resistance at Pitch Line of Worm, Lb
Tooth Load, Lb.
AW-2 1232 R.p.m. (Corrected) 16°45' Helix Angle
AW-3 922 R.p.m. 41°45' Helix Angle
AW-1 1550 R.p.m. 11° 8' Helix Angle
GEAR RUBBING SPEED
● AW-1 821 Ft. per min.
× AW-2 768 Ft. per min.
○ AW-3 743 Ft. per min.

FIG. 8 FRICTIONAL RESISTANCE PLOTTED AGAINST TOOTH LOAD—WORM DRIVES AW-1, AW-2, AND AW-3

checked with reasonable accuracy by calculations based on the temperature rise and the area of the exposed surface of the case. Such power losses might be established as "case factors" for any specific drive. A series of such tests with different lubricants at different speeds would give valuable data as to the influence of different types of lubricants and different oil levels on these power losses.

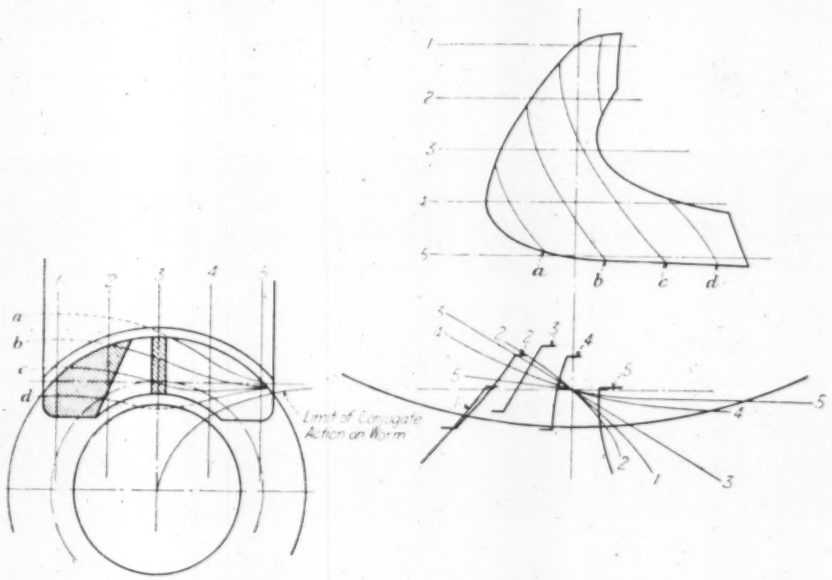


FIG. 9 FOUR-THREAD WORM DRIVE AW-4. CONTACT LINES FOR EACH HALF-PITCH ADVANCE

(3-a-2) *Bearing Losses.* The power losses in plain bearings depend primarily upon the amount of the load, the rubbing velocity, the viscosity of the lubricant, and the bearing area.

The power losses in ball bearings depend primarily upon the amount of the load and the speed of rotation. Only when these bearings are submerged in oil does the viscosity of the lubricant have any appreciable influence.

With plain bearings the coefficient of friction is high at very low speeds and decreases rapidly until the rubbing speed reaches a speed of about 100 ft. per min.; then it rises slowly again, increasing approximately as the square root of the velocity. These coefficients of friction change to some extent with a change in load.

With ball bearings, the coefficient of friction is practically a constant at all speeds and loads; that is, the power loss is directly proportional to the power transmitted. Existing data can be used to estimate these bearing losses very closely.

(3-a-3) *Worm Contact Losses.* The power losses because of the rubbing between the worm and gear depend primarily upon the nature of the contact, the characteristics of the lubricant, the rubbing speed, and the intensity of the load.

All of these factors are closely interrelated, and many of them are variables. Thus an increase in load may increase the overall power losses, which will increase the operating temperature and reduce the viscosity of the lubricant. A decrease in the viscosity might reduce the churning losses slightly, but might increase the worm contact losses still more, etc. This suggests but one example of the complexity of this whole problem.

The coefficient of friction at the worm mesh probably varies both with the load and the rubbing velocities. In most tests, particularly where small amounts of power are transmitted, the power lost in churning the oil and the bearing losses are probably so large in proportion to the power lost at the worm mesh itself that the characteristics of the friction losses at the worm mesh are considerably masked. It would seem, however, that under very light loads the frictional conditions here may approach those of fluid friction, while at the maximum or limiting loads they would begin to approach those of solid friction.

It thus seems probable that under the many varying conditions on different worm drives, all types of friction are sometimes present; namely, fluid friction, friction of semi-lubricated surfaces, and in the most extreme cases, solid friction. The friction of any worm drive operating at a given speed would probably pass through all of these phases in order as the loads were increased, starting with fluid friction under very light loads. We find in "Practice of Lubrication," by T. C. Thomsen, the following laws of friction:

Fluid Friction. The frictional resistance with fluid friction

a Is independent of the pressure between the surfaces

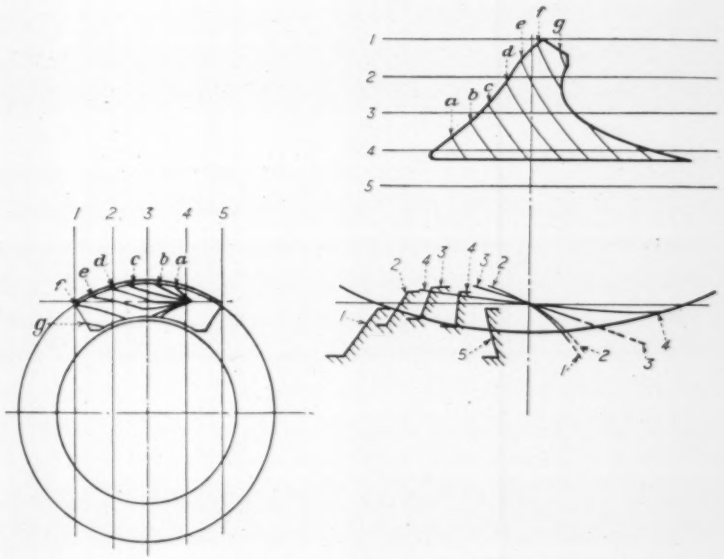


FIG. 10 NINE-THREAD WORM DRIVE AW-5. CONTACT LINES FOR EACH HALF-PITCH ADVANCE

b Increases with speed of rubbing surfaces

c Increases with area of rubbing surfaces

d Is independent of the condition of the rubbing surfaces or the materials of which they are made

e Depends entirely on the viscosity of the lubricant at the working temperature of the oil film.

Semi-Lubricated Surfaces. There are no definite laws governing the friction of semi-lubricated surfaces. The frictional resistance is composed partly of solid friction and partly of fluid friction, and the more the solid friction predominates, the more

important is the property known as oiliness and the less important the viscosity of the lubricant.

Solid Friction. The frictional resistance with solid friction is

a Directly proportional to the total pressure between the surfaces
b Independent of the rubbing speeds at low speeds, but decreases at very high speeds
c Independent of the areas of the surfaces
d Dependent to a considerable extent on the roughness and hardness of the surfaces.

There are so many possible combinations of loads, speeds, and lubricants that no single curve can be drawn which will represent graphically the power loss at the worm mesh. We shall attempt, however, to so picture a few of these possible combinations.

We shall assume a drive operating at a constant speed. In Fig. 12 are drawn two curves representing the change in the power losses as the load is increased, curve *A* representing the conditions with an oil of low viscosity, while curve *B* represents the losses with an oil of higher viscosity. As long as fluid friction is present, the lower-viscosity oil gives a smaller power loss. Fluid friction may be maintained, however, under heavier loads with an oil of higher viscosity; hence at some point the two curves will cross each other, and under the more severe load conditions the oil of higher viscosity will show the smaller power loss. These two curves are based on two lubricants of the same general characteristics except for the viscosity. This condition exists in test AW-5, and the graph of those tests, Fig. 11, shows such a crossing of the two curves as that in Fig. 12.

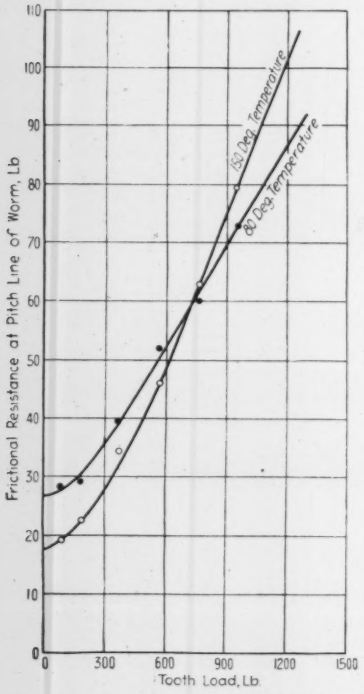


FIG. 11 WORM DRIVE AW-5. FRICTIONAL RESISTANCE PLOTTED AGAINST TOOTH LOAD

If the oil of lesser viscosity is of a greater oiliness than the other, although the two curves might start out as before and cross each other, under extreme conditions of load, curve *A* would be flatter than curve *B* so that the two curves would cross each other again, and the oil of lesser viscosity but greater oiliness would again show a smaller power loss than the other. Such a condition is represented in Fig. 13 by curves *A* and *B*.

As another example we shall consider some of the possible conditions with constant loads at varying speeds. As the power loss is small at very low speeds, although it may be a very large percentage of the power transmitted, the change in the frictional conditions will show up more distinctly when the curves represent the change in the frictional resistance rather than the power loss itself. When the speed is constant, the shape of the curve is the same whether it represents frictional resistance or power loss.

Under very light loads when fluid friction is maintained, the frictional resistance is dependent upon the rubbing speed and the viscosity of the oil at its working temperature. This might give us practically a straight line as shown at *A* in Fig. 14. An increase in load would not change the frictional resistance so long as fluid friction was maintained. If an oil of greater viscosity were used, we should have the curve *B* to represent similar load conditions. This line would start a little higher and probably rise a little faster than the first line.

If the load were increased so that a perfect oil film could not be maintained, we should have the conditions represented by

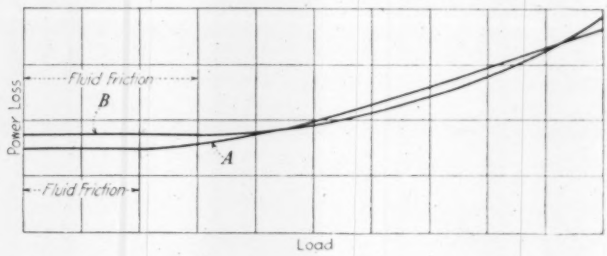


FIG. 12 VARIATION OF POWER LOSS WITH INCREASING LOAD—CONSTANT SPEED

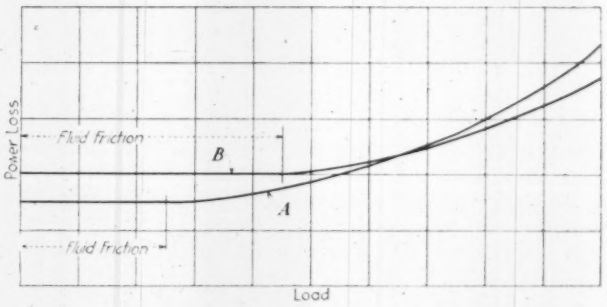


FIG. 13 VARIATION OF POWER LOSS WITH INCREASING LOAD—CONSTANT SPEED

curve *C*. Here the static or starting friction would be very high. The frictional resistance would reduce rapidly to a minimum as the speed was increased, and then rise again slowly with a further increase in speed. The higher the load, the more pronounced the form of this curve will be. This general condition is very apparent in the graph of test AW-1, Fig. 3.

Under these same conditions with an oil of greater viscosity we should have the conditions represented by curve *D*. Here the static or starting friction is lower, but after the frictional resistance had reached its minimum it would rise faster than with the lighter oil.

In general, the graphs of the test data seem to indicate that the conditions are very similar to those outlined in this very incomplete analysis.

A considerable amount of data has been received which shows the wear or life of worm drives under service conditions. Test AW-4 is one example of this type of information, and several more are now in process of investigation. We shall therefore consider item 1, pitting of tooth surfaces, in some detail, and set up tentative methods of analysis for the purpose of making direct comparisons of these data.

PITTING OF TOOTH SURFACES CONSIDERED IN MORE DETAIL

(1-a) *Physical Properties of the Materials.* Most of these have already been established for the materials commonly used

in the construction of worm drives, although reliable information on compressive strength and compressive fatigue is conspicuous by its absence.

(1-b) *Size, Form, and Nature of Contact Between Worm and Gear.* In many respects the contact between a worm and gear as regards the maximum compressive stresses set up is very similar to that between spur gears, so that a reasonably true measure of these stresses should be obtained by using a similar method of analysis. Therefore we shall tentatively use the following expression for this purpose:

$$W_s = DFKQ \quad \ldots\ldots [1]$$

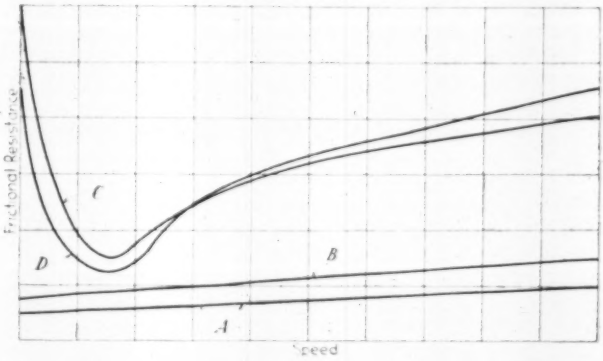


FIG. 14 VARIATION OF FRICTIONAL RESISTANCE WITH INCREASING SPEED—CONSTANT LOAD

where W_s = equivalent static load, lb.
D = pitch diameter of worm gear, in.
F = minimum length of contact, in. (This length to be the projected length of contact lines on plane perpendicular to axis of worm.)
K = load-stress factor. (Same as for spur gears.)
K = 75 for hardened steel worm and bronze gear. (This value gives a probable factor of safety of about 2.)
Q = curvature-ratio factor and will vary from about 2 to 6, depending upon the nature of the contact lines. In the case of most of the drives of conventional design, the value of 2 should be used.

(1-c) *Accuracy of Worm and Gear and Alignment.* This accuracy controls the amount of the theoretical contact which is actually obtained, as well as influences the intensity of the maximum loads set up when the drive is in operation. With reasonable accuracy, the drive will tend to wear to more nearly complete contact. If the errors are large, however, the tooth surfaces may start to abrade before full contact is secured, and when this abrasion is excessive, the tooth surfaces will be too far destroyed to ever match and polish down again.

(1-d) *Intensity of Applied Load.* As with other gears, the intensity of the maximum instantaneous load will depend upon the characteristics of the materials, the extent of the errors, the velocity of the engagement, the magnitude of the effective masses, and the amount of the load to be transmitted.

(1-e) *Velocity of Engagement.* The velocity of the engagement as it affects the intensity of the maximum impact load is probably very similar in its influence to that of other types of gears. The helical action of the worm thread probably softens the impact conditions set up by minor errors, so that the mating profiles may never actually leave contact with each other. Under such conditions, the maximum load would be a suddenly applied one with double the intensity of the working load. Therefore for the purposes of preliminary analyses and comparison we shall tentatively use the following equation as a measure of the influence of the pitch-line velocities.

$$W = W_s \left(\frac{100}{200 + V} + 0.50 \right) \quad \ldots\ldots [2]$$

where W_s = equivalent static load, lb.
W = transmitted tooth load, lb.
V = pitch-line velocity of worm gear, ft. per min.

This equation gives us the following velocity factors:

V	Velocity factor	V	Velocity factor
100	0.833	1100	0.577
200	0.750	1200	0.571
300	0.700	1300	0.567
400	0.667	1400	0.563
500	0.643	1500	0.559
600	0.625	1600	0.556
700	0.611	1700	0.553
800	0.600	1800	0.550
900	0.591	1900	0.548
1000	0.583	2000	0.545

(1-f) *Nature of Service.* Practically all test data are based on steady load conditions. Where more severe conditions have to be met, smaller load values must be used. It may be possible to establish service factors for the different types of service which must be performed. Experience seems to indicate that these factors would vary from about unity for steady load conditions to about one-third for the most extreme conditions. In other words, a drive subjected to intermittent shock or overload conditions could only carry a normal load of about one-third of what it should carry under steady load conditions. This factor must be taken into consideration when comparisons of service data are made.

Taking drive AW-4 as an example of the use of these tentative equations, we have the following factors for the solution of Equation [1]:

D = 20.770 K = 75
F = 5.50 Q = 2.0

whence $W_s = 17{,}135$ lb.

For Equation [2] we have V = 215, whence

$$W = 0.74\, W_s$$

The actual tooth load developed by transmitting 20 hp. is equal to 3070 lb. According to the foregoing equations, the safe maximum load as far as fatigue is involved on this drive is 17,135 × 0.74 = 12,680 lb., or about four times the actual load. This safe load includes a factor of safety of about 2.0, so that the actual load is about one-eighth of the critical load, or a contact line one-eighth of the theoretical one of 5.500 in. should just carry the load. This checks very well with the actual conditions found on this drive in service, because after contact was made over a surface of from 1/2 in. to 3/4 in. in width, further wear was not apparent.

THE RESULTS of experiments have shown that almost any desired range of cooling rate, for the quenching of steel, between those of oil and water, can be attained by the use of glycerine-water solutions of various concentrations. The cooling rate of steel decreases continuously with the addition of glycerine to water, and more rapidly as the percentage of glycerine is increased, pure glycerine being slightly below oil; hence glycerine and water solutions effectively bridge the gap between oil and water.—*The Engineer* (London), Nov. 16, 1928, p. 547.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

ENGINEERING MATERIALS (See also Machine Parts: Steel-Valve Defects; Special Processes: Centrifugally Cast Iron Pipe)

FUELS AND FIRING

The Norton Patent Automatic Washer

THIS is a box-type washer working on the Bau principle in the sense that the water pulsation is caused by air. The Norton box was designed with a water chamber at each end of the box arranged so that the elevator buckets collect the shale from the bottom of this water chamber. The shale gates are located in these water chambers, and are pivoted so as to rise and fall with the partial rotation of the pivot shaft.

An entirely new principle of shale discharge from the washing bed is adopted. The shale pulsates out from the washing bed on to a shelf projecting into the external water chambers. At the end of the shelf the pivoted gate is raised (by counterbalance) above the shelf level, in the manner of a weir, to prevent egress of the shale until it has reached a suitable working depth on the washing bed. In conjunction with each pivoted gate is a cylinder mounted on top of the wash box. This cylinder has a small piston valve to admit air from the washer-box pressure supply.

The floats situated near each end of the washing bed are continuously indicating the level of the shale, and at the same time are in communication with the piston valves of the air cylinders ready to operate the shale outlet gates. The operation is as follows:

When the shale in the bed has reached a little higher than the best working level, the float moves the piston valve, and the main cylinder piston operates the shale outlet gate or weir by depressing it so that the shale on the shelf is pushed off by the pulsating shale bed. This lowers the general level of the shale to the correct working level. The lowering of the float then causes the return of the valve and the main cylinder piston, thus allowing the shale gate to rise and retain the shale in the bed until an excess is again present. The operation of the float and shale outlet gates requires no attention. Their function is entirely automatic.

It should be noted that the air operation of the shale gate is only for opening it; the return of closing operation is directly performed by the application of the balance weight, cord, and pulleys. This method is adopted to insure that the gate is always closed when the plant is shut down.

The patented arrangements make the washing results consistent and entirely independent of the human element.

The same company has developed a unit washer in which all the operations of washing are combined.

In the "Norton" patent unit washer all main shafting and belt drives, together with all pipe lines, have been cut out. The receiver and the blower are mounted on the wash box. They are connected together with one pipe which is fitted the deadweight release valve. The air piston valves of the wash box itself are set at an inclination, and are directly coupled to the receiver. Mounted on the same bed with the blower is the driving motor, the blower being driven through machine-cut gearing. From the blower there is a roller-chain drive to a lineshaft of the self-contained unit. This lineshaft is fitted with eccentrics which operate the air piston valves of the box, and with pinions driving the refuse elevators. The power transmitted by this shaft is only about 6 hp.

In refuse elevators it is necessary that any tension should be applied at the top. In this patented construction the head shaft moves through a curved path when applying the tension, enabling the gears to maintain perfect meshing with varying positions of the head shafts. (*The Colliery Guardian*, vol. 137, no. 3545, Dec. 7, 1928, pp. 2265–2266, 1 fig., *d*)

Consumption of Bituminous Coal in the United States

NO PERFECT precision is claimed for the figures stated below. Excluding exports and allowing for changes in stocks, the annual consumption of bituminous coal in the United States is now about 500,000,000 tons. In the last decade it has fluctuated between a minimum of 390,000,000 tons in 1921, a year of acute industrial depression, and a maximum of 533,000,000 tons in the active year 1926, when the demand was stimulated by a strike of the anthracite miners. In 1927 the consumption was 499,700,000 tons, and in 1928, according to present indications, it will be slightly less.

As the total consumption of energy in the United States is now equivalent to one billion tons of coal, it is seen that bituminous coal furnishes a little over half the country's total requirements. The relative importance of the other sources is shown in a figure in the original article which covers the year 1927. Including anthracite, coal furnished 58.4 per cent of the total. Oil and natural gas now contribute more than one-fourth of the whole. Contrary to popular impression, water power supplies only a little over 6 per cent. Five and one-half per cent is derived from firewood, which is still widely used in some sections of the country. Work animals, once the dominant source of motive power, now furnish only 2.5 per cent.

How large a part of the total consumption is concentrated in a few relatively small areas is seldom appreciated. Seventy-three per cent of the bituminous coal is used in the industrialized section north of the Ohio and Potomac Rivers and east of the Mississippi, yet even in this region there are areas of sparse consumption, and the great bulk of the tonnage is consumed in a small number of manufacturing centers, of which Pittsburgh, Chicago, Cleveland, New York, and northern New Jersey, Youngstown, Detroit, Buffalo, Johnstown, Philadelphia, Boston, Baltimore, Bethlehem, East St. Louis, and Cincinnati are the most important. Some idea of the high degree of concentration of the industrial demand is conveyed by the fact that 85 of the 3093 counties in the United States consume 51.8 per cent of the coal required by industry.

Over the country as a whole slightly more than half of the product is still shipped as run of mine. In 1927, run of mine constituted 50.2 per cent of the total bituminous shipments, prepared sizes 29.3 per cent, and screenings or slack 20.5 per cent. The relative proportions of prepared sizes and run of mine vary widely in different parts of the country, depending on the demands of the market. In areas where much coal is sold for household fuel the bulk of the product is screened and sized, and the proportion shipped as run of mine is correspondingly low. In Franklin County, Illinois, for example, only 9 per cent of the shipments in 1927 were run of mine, 59 per cent being prepared

sizes and 32 per cent screenings or slack. On the other hand, areas where the domestic trade absorbs a small part of the production are characterized by high percentages of run of mine. In the markets accessible in central Pennsylvania, anthracite is the usual domestic fuel, and the demand for bituminous for household use is small. It is therefore not surprising to find that over much of this district 90 per cent or more of the shipments are in the form of run of mine.

The seasonal character of the consumption of coal is emphasized, the general tendency being to use more coal in winter than in summer. This applies not only to domestic consumption but also to the consumption by industries and railroads. The seasonal character of consumption is apt to affect all projects for the processing of coal. In proportion as the demand for the product is seasonal, the matter of storing both the processed fuel and the by-products during slack periods must be taken into consideration.

As regards consumption by users, the steam railroads are by far the largest consumers, taking 27.7 per cent of the total. Of this, 128,000,000 tons are for locomotive fuel and about 15,000,000 tons for shops, roundhouses, stations, and office buildings. Coke ovens with close to 83,000,000 tons, or 16 per cent of the total, come next. The electric utilities consume only about 40,000,000 tons, or 7.7 per cent of the total, which is less than might be expected and is due to the high thermal efficiencies that they have attained. The iron and steel industry with 5.4 per cent of the total comes next, while the general manufacturing industries take 1,000,000 tons or 19.5 per cent of the grand total.

One of the most significant facts about coal consumption is that the rapid growth which was so conspicuous in the period before the war has been checked. Had the former rate of growth, as indicated by prewar experience, continued since the war, the demand in 1927 would have amounted to some 680,000,000 tons, while the actual production in that year was 517,000,000 tons. The causes underlying this change in trend of consumption are mainly as follows: First comes the rapid growth of the other sources of energy, particularly water power, oil, and natural gas. Of equal importance has been the great improvement in the efficiency of fuel utilization both in the field of power generation and direct application of heat. In this connection an analysis is made of several certain important fields of coal consumption, such as, for example, railroads. In this field there has been an increase in traffic, which would have meant larger consumption if it had not been offset by the marked improvement in fuel efficiency. Further improvement in fuel efficiency is indicated. The average consumption in the freight service in 1927 was 131 lb. per 1000 gross ton-miles, but the Union Pacific Railroad reports a locomotive that uses only 70 lb.

In the iron and steel industry likewise the volume of the product is increasing, but advances in fuel efficiency have brought about an actual reduction in the total consumption of coal.

The volume of the product may be measured by adding together the tonnage of pig iron and half of the tonnage of steel, since it requires about half as much fuel to convert the pig into finished rolled products as it does to convert the ore into pig. The curve representing the two combined shows a very large increase in volume of product since 1913. In comparison with the war period many of the post-war years show a decrease, but it must be remembered that from 1916 to 1918 the production of steel was stimulated by the demand for munitions. Even on this basis, the active year 1926 shows an increase of 4 per cent over 1918.

Meanwhile, rapid progress has been made in fuel economy. In 1904 the ratio of tonnage of coal used (including the equivalent of fuel oil) to tonnage of product was 2.01; in 1914 it was 1.8; and by 1927 it had fallen to about 1.4. The reduction in unit fuel consumption would appear still greater if it were possible to include data on natural gas, which has been declining in relative importance. The highest element in this saving has undoubtedly been the substitution of by-product for beehive coke. The gas, tar, light oil, and breeze recovered at by-product plants in 1927 had a heat value equivalent to 15,600,000 tons of raw coal, as against 700,000 tons in 1904. It should be noted that the economies resulting from by-product coking approach a limit as the displacement of beehive coke becomes more nearly complete.

Displacement of coal by fuel oil in this industry has been very small.

The net result of the several factors has been a sharp reduction in the total consumption of both gas and steam coal and coking coal by the iron and steel industry. In comparison with 1916, the active year 1926 shows an increase of 2,700,000 tons in volume of product but a decrease of 15,000,000 tons in the consumption of bituminous coal.

Even more striking have been the changes in the consumption of the electric utilities. The business of the utilities has grown by leaps and bounds like a sum at interest compounding at the rate of 10 per cent. In the last 25 years the total production of electric power by central stations and electric railways has increased nineteenfold. Part of the increase is due to the development of hydro power; but the production of fuel power has risen from 4,000,000 kw-hr. in 1902 to about 52,000,000,000 in 1928, an increase of thirteenfold. The consumption of coal has increased during the same period, but in much smaller ratio. In 1902 the utilities used, in round numbers, 11,000,000 tons; in 1928 they used 41,000,000, an increase of less than fourfold against the thirteenfold increase in power production.

This astonishing result has been made possible by improvements in fuel efficiency. In 1902 the average consumption per kilowatt-hour was about 6.6 lb. By 1917 this had been cut to 3.3 lb. Particularly rapid progress has been made since the war, and in 1927 the average fell to 1.83 lb. Even this is much above the performance of the best plants today, and one station on the Ohio River below Cincinnati has touched a record of 0.86 lb. per kw-hr. generated.

Competition of oil and natural gas has been a minor factor in the coal requirements of the utilities. The use of these other fuels reached its maximum in 1924, when oil and gas equivalent to 5,500,000 tons of coal were consumed. Since then the consumption of oil has been declining, and the total of oil and gas in 1927 was equivalent to but 4,022,000 tons of coal, or 9 per cent of the total fuel consumption of the utilities.

The net result of these factors has been to hold the total coal consumption of the utilities virtually constant for the last four years. Indeed, the consumption for the first ten months of 1928 was slightly less than for the corresponding period of 1927.

In the general manufacturing industries the coal requirements in one group have decreased as a result of substitution of central-station power for individual power plants, while in another group (industries consuming fuel chiefly for direct application of heat, such as the manufacture of cement, glass, and lime) there has been a continuous increase. There has been also an increase in the consumption of bituminous coal for heating buildings, and it is of interest to note that most of this increase in the heating load has gone to bituminous coal rather than anthracite.

As to the probable trend of demand in the future the writers venture no prediction, although they believe the new data presented in this paper will be helpful to others who may undertake a forecast. It seems clear that the total demand for power and heat in all forms, which is still increasing at a wholesome rate, may be expected to continue its growth. It will not only grow with population, but the per capita consumption will probable increase.

It is also clear that whatever of this total demand for energy is

not supplied by oil, gas, and water power is limited. The great variable, the most uncertain factor in the future of coal, is the consumption of oil and gas. Most observers expect the production of petroleum to decline sooner or later, and when it does a corresponding increase in coal consumption may be anticipated.

As to the factor of fuel economy, all will agree that the present rapid rate of improvement in fuel efficiency is not likely to continue indefinitely. The progress since 1917 is largely a taking up of slack, a general adoption of principles already known to engineers. On the other hand, the advances in efficiency give no promise of bringing average performance nearer to the level of what the best performance has already indicated is possible. (F. G. Tryon and H. O. Rogers in a paper before the Second International Conference on Bituminous Coal, Nov. 19–24, 1928; abstracted from preliminary publication by News Service, Carnegie Institute of Technology, Pittsburgh, Pa., *gs*)

INTERNAL-COMBUSTION ENGINEERING

Crankless Engines for Boosting Gas Pressure

THE largest gas-boosting system in Australia, The Australian Gas Light Company, includes twelve units of unusual design for stepping up the city gas pressure. Each engine-compressor unit consists of a booster driven by a gas engine through a flexible coupling, the engine using as fuel a small fraction of the gas that is being boosted. The engine, which is of the Michell crankless type, works on the four-stroke cycle, but instead of a crankshaft has a slant member or wobble plate mounted on the main shaft. Eight cylinders are arranged in pairs equally spaced around the "slant." Each pair of pistons is coupled together by means of a bridge and arranged so that the thrust is transmitted on either side of the slant by means of a Michell thrust slipper with a spherical seat.

The engine has eight cylinders, while the booster compressor has twelve double-acting cylinders arranged in two groups of six at each end of the machine. The engine is started by means of a 12-hp. 3-cylinder gas engine of the crankless type. (Louis H. Rouillion in *Power*, vol. 68, no. 25, Dec. 18, 1928, pp. 994–995, 2 figs., *d*)

The Expansion of High-Temperature Gases in Nozzles

EXPERIMENTS were carried out to measure the coefficients of velocity and of discharge and the heat losses associated with two nozzles of simple form expanding high-temperature and high-pressure products of combustion of gaseous fuel—conditions identical with those occurring in internal-combustion turbines.

The tests were made with convergent, divergent, and convergent-parallel nozzles. The main conclusions drawn from these experiments, relating solely to the functioning of the nozzles, are as follows: (1) The coefficient of discharge increases, and the coefficient of velocity decreases, as the initial gas temperature is raised. (2) The relationship between the coefficients and the initial gas pressure is similar at all initial gas temperatures. (3) The heat losses in the nozzles are considerable, and are similar in magnitude to those occurring during the expansion stroke of an internal-combustion engine for comparative wall temperatures. (4) The experiments afford no evidence bearing upon the relationship between frictional reheating effect (depending on ϕ^2, where ϕ is the coefficient of velocity) and the heat loss to the cooling water. If, however, these are independent of one another, then in all cases the increase in outlet gas temperature due to friction exceeds the defect in temperature due to heat loss. In other words, the actual temperature drop in the nozzle appears never to have been greater than the theoretical. (5) Each nozzle showed signs of corrosion internally at the conclusion of the tests. (6) A very greatly extended series of experiments is necessary before the relationships between coefficients, nozzle temperatures, and heat losses can be formulated. (C. E. Wadlow, Ph.D., in a thesis deposited in the Library of the University of Birmingham, England; published in abstract in the *Proceedings of the Institution of Mechanical Engineers*, no. 2, 1928, pp. 405–415, 10 figs., *e*)

The Lorenzen Gas Turbine

ONE of the most important features of this turbine is the method of cooling the blades, which is done in this case from the inside out by means of a flow of compressed air through the rotor. Essentially both air cooling and the use of hollow blades are not new, but in this case the compressed air used for cooling the blades is produced by the turbine itself in a very simple manner, namely, by placing inside of the turbine rotor a blower wheel rotating in step with the turbine rotor. This has the further advantage that the cooling air leaves the compressor rotor in a direction which permits it to enter the hollow blades of the turbine rotor without shock. The heat given up by the air in cooling is partly recovered by using the air in the combustion cycle of the turbine itself. This turbine has not been

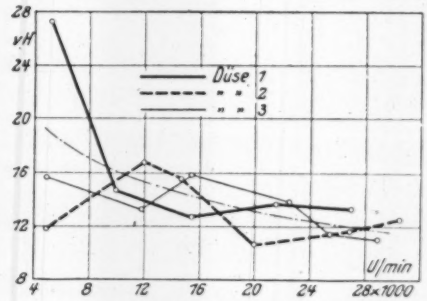
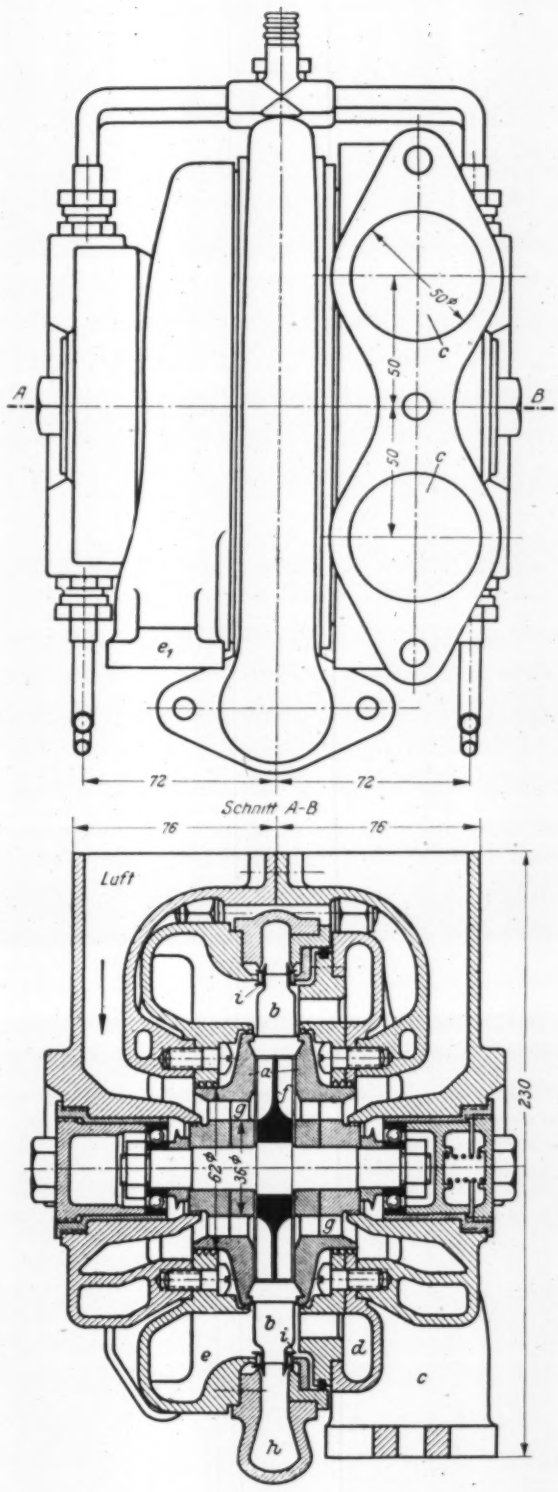


FIG. 1 CURVES SHOWING TOTAL EFFICIENCY OF THE EXHAUST-GAS TURBINE
(*Düse* = nozzle; *vH* = per cent; *U/min.* = r.p.m.)

used as a prime mover and has been only employed to utilize the exhaust gases of high-speed combustion motors. A very extensive series of tests on the Lorenzen exhaust-gas turbine was carried out by the German Aeronautical Experimental Laboratory at Adlershof in 1926, the official report of these tests being dated November 5 of that year.

The general construction of a Lorenzen turbine is shown in Figs. 2 and 3 and its simplicity is evident from an illustration in the original article showing the small number of parts in the turbine. In the tests the gas turbine was set over the terminal of the exhaust manifold of a 300-hp. Hispano-Suiza aircraft motor. After leaving the turbine the gases were either permitted to exhaust into the open air or were forced by an additional blower into a container equipped with means for determining the volume of the gases at their issue therefrom. The results of the tests are given in a series of curves.

Among other things it has been found that the drop in temperature of the gases in going through the turbine is not large, and this justifies the belief that it will be possible to transfer a good share of the heat content of the gases to the air used in combustion. This, however, can be done only with a pure gas turbine and not with the turbine used as now and driven by the exhaust gases themselves. It does not appear that the presence of the turbine creates sufficient back pressure to affect the operation of the motor. From Fig. 1 it would appear that even in the very simple form in which it is now available, the turbine running at from 10,000 to 25,000 r.p.m. is capable of converting from 12 to 16 per cent of the energy of the exhaust gases into useful work of the blower, the efficiency increasing as the speed falls off. From this



FIGS. 2 AND 3 LORENZEN EXHAUST-GAS TURBINE AS INSTALLED ON A MERCEDES SUPERCHARGED-TYPE AUTOMOBILE
(*Schnitt A-B* = section through *A-B*; *luft* = air.)

it would appear that there is a possibility of increasing the thermal efficiency of the motor by means of the turbine.

A smaller turbine than the one used in the tests at Adlershof but of substantially the same design has been built (this is really the turbine shown in Figs. 2 and 3) to work with a 10-hp. Mercedes supercharged-engine-type of car to take the place of a previously used Roots blower. The exhaust gases go directly into the housing of the gas turbine and leave it in an upward and outward direction with so slight a pressure that the exhaust is practically silent, even though no muffler is used. The hot compressed air which is provided by the blower is delivered to the carburetor. Its heat is utilized in accelerating the evaporation of the fuel already atomized in the carburetor nozzle, and this, together with the higher pressure prevailing in the mixture, improves the ability of the engine to deliver power, particularly at the lower speeds, and also facilitates the employment of less volatile fuels. It is particularly important that the blower shall begin to deliver compressed air even when the motor speed is very

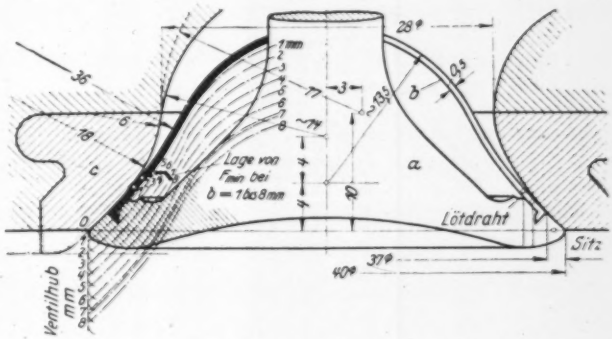


FIG. 4 EXHAUST VALVE OF THE LORENZEN NOZZLE TYPE
(*Ventilhub* = valve lift; *lötdraht* = weld; *sitz* = seat; *lage von* $F_{min.}$ *bei* = 1 *bis* 8 *mm.* = location of $F_{min.}$ when b = 1 to 8 mm.) (No definition of $F_{min.}$ is given in the original article.)

low, which is just the time when a higher motor torque is so desirable.

In Figs. 2 and 3 the turbine rotor proper consists of two steel disks *a* which hold the hollow turbine blades *b* between their outer edges in undercut circular grooves. These blades are pressed from thin alloy-steel tubing in such a manner that in their middle part they have the exact blade shape, while at their outer ends they are made rectangular. The exhaust gases from the motor enter by passages *c* into the chamber *d*, and after passing through the turbine blades, flow through the passage and *e* vertically downward through e_1. Between the disks *a* is held the rotor *f* of the blower, which draws in air through the passages *g* of the turbine disks and forces it through the hollow blades into the diffuser *h*. The rectangular edges of the turbine blades open into this space and are equipped with labyrinth ring packing *i*, the purpose of which is to permit the escape of as little compressed air as possible from the diffuser into the exhaust chamber *e*. The gas-turbine shaft, which does not project outside its housing, runs in ball bearings. This housing is cooled by the flow of air from the outside as well as by the cooling water of the motor. The external dimensions of the gas turbine as a whole are approximately the same as those of other types of motor blowers, so that the turbine can be easily installed in an ordinary automobile. The changes in the piping required by its installation are also comparatively simple. The car with this type of blower is said to have been in operation for several months without any special troubles developing.

Among other things, Lorenzen had the idea that he could increase the velocity of the exhaust gases as they leave the motor

cylinder. To do this he proposed to give to the openings produced by the lift of the exhaust valve the shape of nozzles. Fig. 4 shows how this was done by providing the exhaust valve *a* with a sheet-iron cap *b*, the lower edge of which is welded on above the valve seat while the valve seat *c* has a uniform curvature beginning with the conical seat surface proper.

The narrowest cross-section of the opening of such a valve does not increase uniformly with the increased lift of the valve, but more slowly so that the maximum velocity of the exhaust gases is maintained during the entire period of the valve lift. (A. Heller in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 72, no. 51, Dec. 22, 1928, pp. 1869–1872, 13 figs., *d*)

MACHINE PARTS

Steel-Valve Defects

THIS article deals with investigations carried out by the Walworth Company, Boston, Mass. This company has completed a series of tests of the physical properties of cast steel at temperatures ranging from 70 to 1200 deg. fahr. From these tests the physical properties of steel castings necessary to withstand high temperatures and pressures were determined. However, it was an entirely different matter to secure such properties in foundry practice. Part of this work, particularly that of the X-ray testing of metals, was carried out at the Watertown Arsenal.

Early in the investigation it was found that the shrink heads or risers were far too small, and the engineers learned that success of steel-foundry work largely depends on the proper application, location, size, and shape of shrink heads. As a result of this, carefully designed shrink heads were made as integral parts of each pattern, thus insuring the use of standardized shrink heads every time the pattern is run in the foundry.

The next problem was the determination of the proper heat treatment for high-pressure castings. Steel of any given analysis attains its highest quality when its chemical and molecular structure is of a certain definite nature. Steel as cast is seldom in this desirable condition. This is due to shrinkage strains and to unequal cooling. To overcome these factors it is necessary to subject the castings to a heat treatment. There are many ways of doing this, and, because of the large number of variables involved, the subject is one where standardization is difficult. However, it is generally understood by those engaged in the work that this phase of steel-foundry practice requires as careful attention as any other.

A fourth field of investigation conducted by the Walworth engineers has been that of design of the fittings themselves for best structural features. This includes working tolerances in machining as well as tests of the materials other than castings. At temperatures above 500 to 550 deg. fahr., bronze is not suitable as a trim material, and some other material must be used. Nickel-copper alloys have been employed satisfactorily, and experimental work with other alloys is in progress. This development work is of interest, not only in the valve and fittings field but to the entire steel-foundry industry. (Herbert E. Simonds in *The Foundry*, vol. 56, no. 24, Dec. 15, 1928, p. 1012, *e*)

MACHINE-SHOP PRACTICE

The Possibilities of Soluble Oil for Cutting Metals at High Speed

"SOLUBLE oil" is strictly a misnomer, as no oil is soluble in water. What the trade understands as a soluble oil is really emulsified oil or a compound of oil and soap in which the oil is split up into a large number of microscopic globules, each one separated from its neighbors by a layer of soap. It is this soap which is soluble, and the addition of water merely dissolves the soap and still further divides the globules of oil which remain in suspension in the liquid. They are so small that the reflection of light from their surface helps to give the emulsion its familiar milky appearance.

The general lines on which emulsifiable oils for engineering purposes are made are similar. Advantage is taken of a peculiar difference which exists between mineral oils and all the others, in that mineral oil cannot be saponified by any of the known methods by which animal or vegetable oils are turned into soap.

A mixture of mineral and saponifiable oil is treated by one of these soap-making processes, with the result that a compound is formed which will emulsify with water as already described.

Recipes for the manufacture of cutting mediums are in use in several large plants at the present day in England, and in some cases are closely guarded secrets. The ingredients vary, but the result is usually the same, namely, the formation of soap. In very few cases has it proved possible to combine a mineral lubricating oil so as to form a permanent emulsion when water is added.

There are, however, several well-known firms who have solved the problems as far as this stage, the results being pastes or cutting compounds of a semi-solid nature. Some of these give quite good results when properly mixed, forming a creamy emulsion with good lubricating and rust-preventing qualities. Their chief drawback, from the machine-shop point of view, is that great care must be taken with the mixing to prevent lumps of undissolved paste from remaining in the liquid, as these clog the pipes, necessitating stoppage of the machine with consequent waste of time. They are also not entirely free from separation tendencies, and rusting is sometimes noticed.

Pastes which have a resin basis suffer from the defects mentioned in connection with resin oils, with the added troubles mentioned in preceding paragraphs.

One of the fortuitous discoveries directly due to the war was the way to make these paste ingredients into an oil which would mix instantly, and remain in permanent emulsion with water. Furthermore, the material did not cause skin troubles with the women munition workers, neither was it offensive in any way, but proved antiseptic.

The compound as now made has all the appearances of a straight oil, and looks as bright as any of the resin or other oils already mentioned. Recent independent trials conducted in a large engineering works have proved that it can be used even in its original state—i.e., without more water being added—to replace pure lard oil on machines where formerly nothing but lard oil has ever been employed. As the compound contains, in concentrated form, all those constituents of lard oil that are of assistance in machining operations, combined with high-quality mineral lubricating oil, it is claimed to be even superior in its working to lard oil, as the small percentage of water necessary for its manufacture raises the fire test very considerably, and lessens the tendency to burn when heavy work is being undertaken; nor does the oil putrefy or turn rancid after being worked for some time. Furthermore the oil can be diluted to form an emulsion for less important work.

An interesting peculiarity of soluble oils, which may not be generally known to engineers, although mention is made of it in the Government treatise on the subject issued during the war, is that anything over 2 per cent of common salt dissolved in the water beforehand prevents any soluble emulsifying at all. Passengers traveling on overseas liners may remember the difficulty of getting a satisfactory wash in sea water and soap, which is a parallel case. (G. W. Brown-Hutton, Melbourne and Metropolitan Tramways Board, in *The Australasian Electrical Times*, vol. 7, no. 10, Oct. 27, 1928, pp. 770–771, *dp*)

Offset Milling

IN THIS case the cutter is set eccentrically to the work holder, and depth of cut is regulated by varying the distance of offset. From the diagram (Fig. 5) it will appear that parts pass into the path of the cutter in a planetary manner and have to travel through a third of a turn of the table in advancing far enough toward the center of the spindle so that the cutter reaches the bottom of the cut. In other words, making a third of a turn of the table is equivalent to feeding the parts directly toward the spindle the exact depth of the cut, and it does not matter whether the parts are fed straight into the cutter, the cutter straight into the parts, or the cutter and work are brought together in some other way. The rate of approach of the cutter and pieces to each other is the same in any case.

As soon as one part reaches the bottom of the cut, the part which proceeds it is just clearing the cutter and a new part is coming into the cut. For practical purposes, the situation is the same as if the parts were mounted in a row, one against the other. In offset milling the cutting never ceases, notwithstanding the apparently wasted space between two consecutive parts as they are mounted on the machine.

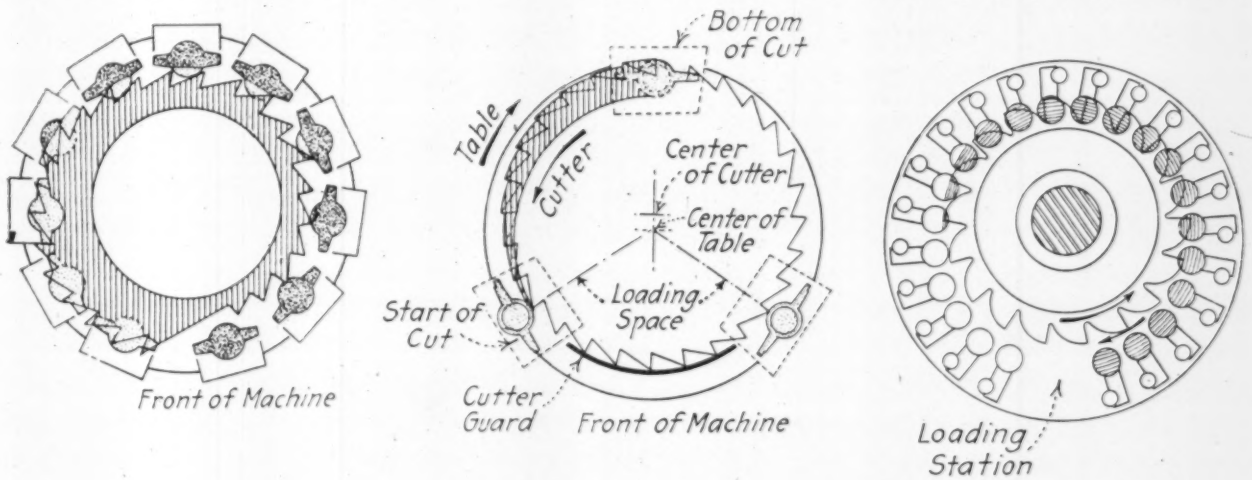


FIG. 5 OESTERLEIN OFFSET MILLING DEVICE, THREE-UNIT TYPE

For practical purposes as many pieces as possible are interposed between each pair of parts shown in the diagram. Fig. 5 shows a three-unit fixture, but more parts, for example, twelve, can be used, in which latter case the production would be increased four times. A smoother finish of the work and less grinding of the cutter are two claims made for the process.

In many jobs when the cutter reaches the bottom of the cut the load is so heavy that it is necessary to reduce the feed. In offset milling this is done automatically. As the part approaches the bottom of the cut the feed gradually tapers off to nothing where the two circles become tangent, from which point the work begins to recede from the cutter.

The new machine is adopted for small face-milling jobs, slotting, straddle milling, sawing, and to some extent form milling. The company which developed offset milling is now putting a tilted offset miller in its own shop and believes it will be economical to mill parts in lots as small as 25 to 50, depending on the nature of the work. [Chas. D. Oesterlein (Mem. A.S.M.E.), Vice-Pres., Oesterlein Machine Co., Cincinnati, in an address at a meeting of the Cleveland and Pittsburgh Sales Forces of the W. K. Stamets Organization, Pittsburgh, December 28, 1928. Abstracted through *The Iron Age*, vol. 123, no. 5, Jan. 31, 1929, pp. 348–350, 5 figs., *d*]

Machinability

THE present abstract comprises part of a report on machinability of the Cutting Tools Research Committee read before the Institution of Mechanical Engineers, London, on December 14, 1928. After recounting previous work, chiefly American, including that of Prof. O. W. Boston (Trans. A.S.M.E., vol. 48, 1926), the report proceeds to a description of the method of testing used. In this case a lathe was used having eight speeds, and the test bar was $1^1/_2$ in. in diameter. The tool, of the knife type, was of high-speed steel, and had a top rake of 35 deg. and a clearance of 7 deg. P. V. Vernon, an expert on workshop practice, who suggested this shape of tool, pointed out that the tool angle should be varied according to the material to be cut, but as it was desired to eliminate all variables except the one under investigation, the tool described was adopted as standard except in one series of tests. The speed was 61 ft. per min. at the periphery of the test bar in all cases where it was practicable to cut at that speed. The feed was such as to give a chip whose actual thickness was just over 1 mm. (0.04 in.) which allowed ample room for hardness tests. The cut adopted as standard was $^1/_4$ in. deep. A coolant consisting of water and a standard cutting compound was used in all tests except in those on cast iron, and all tests were made with roller steadies supporting the work piece.

EFFECT OF SPEED ON CHIP FORMATION

The actual chip thickness was measured and it was found that at the standard speed of 61 ft. per min. the amount of distortion judged by the thickening of the chip, 63 per cent, was less than at higher and at lower speeds, and the average hardness of the chip was also least at the standard speed. The conclusion drawn from these tests, which were of a preliminary character, was that any study of the chip formation at very low speeds can give no guidance as to what occurs under normal conditions, in the same way that a study of chip formation at the very commencement of cutting gives no indication of what occurs when cutting has continued long enough to become normal.

MACHINABILITY

The results of the fundamental machinability investigation are plotted in Fig. 6, the specimens in that figure being placed in the ascending order of their original hardness. All hardness tests and work-hardening tests were made with the author's 4-kg. pendulum hardness tester equipped with a spherical-faced diamond of 0.5 mm. radius.

The diamond time-hardness figures were classified thus: Surface Hardness: This is that of the flat shoulder formed by the tool immediately before the cut was stopped. It has no special significance in relation to machinability, but has an important bearing on the practice, which appears to be fairly prevalent, of making hardness tests on machined specimens and attempting to infer from them the tensile strength of the material. In nearly every case the steel was work-hardened by the tool to a depth comparable with that of a Brinell impression, and many times the depth of a pendulum impression. The hardness of work-hardened material can give no guidance as to the physical properties of the unhardened metal. Path Hardness: This is that immediately in front of the tool edge, that is, the hardness of the material the tool was about to cut when the lathe was stopped.

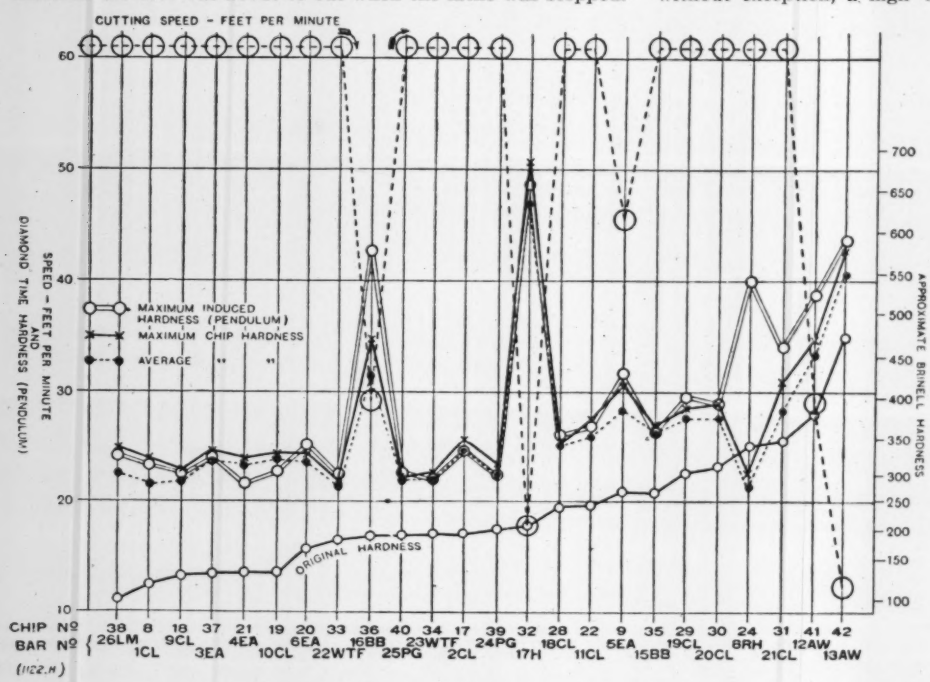

CUTTING SPEED - FEET PER MINUTE
DIAMOND TIME HARDNESS (PENDULUM) AND SPEED - FEET PER MINUTE
APPROXIMATE BRINELL HARDNESS
MAXIMUM INDUCED HARDNESS (PENDULUM)
MAXIMUM CHIP HARDNESS
AVERAGE " "
ORIGINAL HARDNESS
CHIP Nº 38 8 18 37 21 19 20 33 36 40 34 17 39 32 28 22 9 35 29 30 24 31 41 42
BAR Nº 26LM 9CL 4EA 6EA 16BB 23WTF 24PG 18CL 5EA 19CL 6RH 12AW
1CL 3EA 10CL 22WTF 25PG 2CL 17H 11CL 15BB 20CL 21CL 13AW
(1112.H)

FIG. 6 SUMMARIZED RESULTS OF LATHE TESTS (ORIGINAL HARDNESS, INDUCED HARDNESS, AND RELATIVE CUTTING SPEEDS)
(The capital letters in the two lower lines are symbols denoting the various metals tested.)

It is in every case (except that of cast iron) much higher than the original hardness of the metal, but as an indication of machinability it leaves something to be desired. It cannot be ascertained without the rather laborious process of section cutting, and when obtained is a somewhat uncertain quantity by reason of the very steep hardness gradient which exists just ahead of the tool. A difference of a few thousandths of an inch in the position selected for the path-hardness test may considerably affect the results. Maximum Induced Hardness: This is the maximum hardness obtained by rolling the metal with the pendulum in the diamond time work-hardening test, and is a measure of the work-hardening capacity of the metal. Especially noticeable features of these tests are the fact that, in every case, the induced hardness rises to a maximum and declines, and the very different rates at which the maximum is attained in different metals. In practice, the first drop in hardness is taken as an indication that the maximum has been reached. A continuance of the test does not show a progressive decline, but usually a fluctuation at, or slightly below, the maximum. The explanation of the decline is not known. Neither can the explanation or special significance of the rate of work-hardening be given. Slow and quick work-hardening are characteristics of particular metals, but which is the more desirable characteristic is not yet known.

An inspection of many of the hardness charts must inevitably lead to certain definite conclusions. The first and most important of these is that the tool always work-hardens the steel before cutting in. The original hardness of the steel has no significance, and can have no significance, in relation to machinability, since original hardness does not exist in the metal machined; and the same must apply to tensile strength, which is known to be a function of original hardness. Equally obvious are certain conclusions to be drawn from Fig. 6. In every case (with one exception, namely, that of cast iron) a high maximum induced hardness coincides with a high chip hardness, and in every case, without exception, a high chip hardness coincides with a low permissible cutting speed. Original hardness is seen to be quiet unrelated to maximum induced hardness, chip hardness, or permissible cutting speed.

A SIMPLE LAW OF MACHINABILITY

These considerations lead to the formulation, for the first time, of a simple law of machinability, which can be expressed in these words: The measure of machinability is the hardness of the chip.

Chips may vary in hardness according to the character of the tool which produced them, but so does machinability vary with the tool. Thus stainless steel 16 BB was not hardened up to the maximum of which it was capable. This is in accordance with workshop experience in cutting stainless steels. It has been found that they can be cut with least difficulty if an acute-angle tool is employed, as in the present instance. An obtuse-angle tool would harden the chip more. The harder the chip the lower the machinability and the lower the cutting speed, as seen in Fig. 6. The law of machinability takes account not only of the characteristics of the metal, but also of the machining process. In measuring chip hardness as a quantitative guide to machinability, it is suggested that a surface should be prepared on the edge of the chip, not on the flat. Six hardness tests were made across the edge of the manganese-steel chip to ascertain whether any hardness gradients existed, and it was found that the center of the edge was less hard than the inner and outer surfaces, which, moreover, are often in a burnished or corrugated condition unsuited to a reliable hardness test.

According to the law of machinability, cast iron should be the easiest metal to machine, its average chip hardness being only 21.3, which is actually lower than that of any other test bar. This indication of machinability was proved to be correct by sawing tests. The measurement of the hardness of cast-iron chips does not present any insuperable difficulty, but in general it will be unnecessary, as the hardness of the chip varies only slightly from that of the casting. It should be borne in mind that, although cast iron is not work-hardened by a sharp and efficient tool, it may be hardened by a less efficient one. It is

well known that cast iron may be so work-hardened by a blunt hacksaw as to be rendered incapable of being cut. A measure of machinability even simpler than chip hardness is the maximum induced hardness measured by the pendulum time work-hardening test. This quality is seen to be closely related to chip hardness and it gives a similar, but more general, measure of machinability, as it does not depend on the particular form of cutting tool. It is also easier to measure than chip hardness. It cannot, of course, be applied to ascertain machinability in the case of metals and machining conditions which do not produce work-hardened chips.

The complete report describes a series of tests with truncated and compound tools. A certain shape has been found with which the best results are obtained, and it would appear that apart from the slight amount of wear which must take place in starting the cut, i.e., before the permanent edge has been built up, such a tool would continue cutting indefinitely and would never become blunt. The compound tool may be found inapplicable to heavy roughing work, however.

In order to obtain a further measure of machinability and to check the conclusions arrived at from other tests, ten cuts were made through each test bar on a power hacksaw machine and the number of strokes taken in each cut were counted. The easiest of all the test bars to saw was a cast-iron one (8RH), which had a higher regional hardness, a very high induced hardness measured with the pendulum, but a chip hardness lower than that of any other test bar. Thus cast iron conforms with the law of machinability. Certain anomalies appear, however, in connection with steels.

CONCLUSIONS

The following conclusions have been arrived at:

(1) Machining processes change the physical properties of metals to which they are applied. No quantitative relationship can therefore exist between the machinability of metals and the physical properties which they originally possessed and which have not been changed by machining. (2) Since metals differ in their capacity for being hardened by deformation, and machining processes differ in respect of the degree of deformation they produce, machinability is not an attribute of metals which can be considered or measured apart from particular machining processes. (3) The hardness of the chips removed by a metal-cutting process indicates the hardness induced in the metal by that process. It takes account of both the characteristics of the metal and the character of the machining process, and is a measure of machinability. (4) The original hardness of metals gives no indication of machinability. The maximum induced hardness measured by the pendulum work-hardening test gives a general indication in the case of ductile steels, but none in the case of brittle metals such as cast iron, which are separated without deformation of structure. (5) No quantitative relationship exists between the speed at which a metal can be cut, the resistance it offers to the cutting tool, and its blunting effect on the tool. A general correspondence has been found, but subject to important exceptions. (6) In metal-cutting operations, whether conducted with acute-angle or obtuse-angle tools, the actual cutting is done by the built-up edge which begins to form immediately on the commencement of cutting. The efficiency of the cutting process, and therefore the machinability of the metal, depends upon the natural angles of the built-up edge rather than on those of the tool which serves to support it. (7) Very soft steel offers greater resistance to cutting and has a greater blunting effect on the tool than similar steel which has been made harder by heat treatment. This may be attributed to the less efficient natural cutting angles of the built-up edge formed in cutting the softer steel. Highly efficient natural cutting angles have, however, been found, and highly efficient cutting obtained, in soft wrought iron. (8) The edges built up on acute-angle tools are of a temporary or semi-permanent character, being formed and discarded as often as fifty times per second in some cases. Obtuse-angle roughing tools, when used in continuous cutting, form permanent built-up edges composed of many layers welded together and firmly attached to the tool. Obtuse-angle tools used for intermittent cutting, such as sawteeth, form built-up edges which are generally temporary. They may be fully formed in one-tenth of a second or less, and are generally discarded and built up afresh at each stroke of the saw. (9) Acute-angle tools may be caused to form permanently protective built-up edges by grinding them to a truncated or compound-angle shape. The obtuse angle which is to retain the permanent built-up edge should not extend more than 0.5 mm. back from the tool edge. (10) A power hacksaw with permissive feed and a standard sharpened sawblade provide a convenient means of measuring machinability in the workshop. Caution must, however, be exercised in applying results obtained by this or any other cutting process to cutting operations in which the conditions are dissimilar. (E. G. Herbert in *Engineering*, vol. 126, no. 3284 and 3285, Dec. 21 and 28, pp. 789–792 and 803–804, 15 figs., *eA*)

MOTOR-CAR ENGINEERING

The Duesenberg Eight

A CHARACTERISTIC feature of this car is its unusually powerful engine, which has eight cylinders with a bore of $3^3/_4$ in. and a stroke of $4^3/_4$ in. This engine develops 265 hp. at 4200 r.p.m., and is capable of turning up to 5200 r.p.m. No maximum-speed test in high has yet been made, but in second gear the car reached a maximum speed of 89 m.p.h. Incidentally the price of the chassis alone is $8500.

The engine has four valves per cylinder with a double overhead camshaft. The spark plugs are located at the center of the cylinder head and are water-jacketed. The valve stems are water-jacketed almost the full length. The special feature of the camshaft assembly is a mercury vibration damper developed by Mr. Duesenberg. It consists of two cartridges approximately 2 in. in diameter and $3^1/_4$ in. long, each containing 16 oz. of mercury. These cartridges are secured to the cheeks of the shaft. Mercury, because of its specific-gravity–viscosity relation, responds peculiarly to any disturbance, and any vibrations set up in the shaft are damped out almost instantly by the movement of the mercury in the cartridges. Because of the large volume of exhaust gas a special muffler had to be designed. This muffler is 54 in. long. As the gas rushes into the muffler, it strikes an angular baffle plate through which large holes are drilled. Passing through these holes the gas strikes a second baffle plate without holes and is deflected against the radiation surface of the muffler. There is a small passage left between this baffle and the wall, through which the gases enter the next section. There are several such sections, the holes through the baffles decreasing slightly in size as the gases progress toward the outlet. The outer wall is made thin purposely so that the air sweeping over the muffler cools the wall. (M. Warren Baker in *Automotive Industries*, vol. 59, no. 22, Dec. 1, 1928, pp. 790–794, illustrated, *d*)

POWER-PLANT ENGINEERING

Generation of Steam by Blast-Furnace Gas—The "Supermiser"

THE ordinary economizer is not entirely suitable for the recovery of heat from gases leaving the boiler, particularly where higher temperatures are desired. The author believes

that it would be more economical to build a boiler plant so that the gases leaving the boiler are at higher temperatures than is usually considered the best present-day practice, and to allocate the duty of recovering this heat to other parts of the plant specially designed for this purpose. A device which the author developed for effecting heat recovery he calls a "supermiser." It consists of an arrangement of concentric tubes which are surrounded by a casing. The casing is subdivided into three portions by means of two tube plates, and into these tube plates the larger tubes are fixed, one end rigidly and the other a pushing fit. The two ends of the casing are called the "gas boxes" one of which is fitted with a division plate to separate the inlet and outlet gas. Another division plate is fixed to the middle portion of the casing and extends from one tube plate to a point which is of sufficient distance from the other to allow of the passage of air. The products of combustion are induced by a fan through the first pass of annular spaces formed between the outside of the inner tubes and the inside of the outer tubes, and returns by means of the end box through the second pass of annular tubes and thence via the outlet branch into the gas fan. The air is discharged by a fan through the inlet branch and passes along the outer tubes within the casing between the tube plate and the end of the division plate, and returns along the second pass through the outlet branch, and thence to the boiler fronts.

The water passes through two or more tubes in parallel, backward and forward and generally in an upward direction, until it is finally discharged at the outlet connection. The gas, air, and water flow through the "supermiser" at a high velocity. In the case of the gas and air, this is mainly for the purpose of obtaining a high rate of heat interchange. The gas and air currents are directly counterflow, and as these are divided into narrow streams there are no dead cores. The feedwater which is contained in the small tubes also passes generally in a counterflow direction w.th the gases. Thus this arrangement represents an ideal method of heat interchange, as owing to the counterflow principle there is always a large potential head between the fluids which are interchanging temperatures. This enables (1) the outlet gases to be reduced to any low temperature, provided it is above the dewpoint of the gases; (2) the feedwater can be raised to the evaporation point of the steam; and (3) the temperature of the outlet air can be fixed by the proportions in the design so that this may be suitable for the conditions of firing under which the boiler plant is operating.

Charts showing operating conditions in a boiler plant fitted with the "supermiser" and fired with blast-furnace gas are given in the original article. From these it would appear that the approximate combustion temperature of the gases was around 1900 deg. fahr. when working with cold air. The outlet temperature was about 1000 deg. fahr., thus making the useful heat drop 900 deg. With the "supermiser" the air was raised to 450 deg. fahr. and the temperature of combustion to 2140 deg. fahr. The outlet gas temperature was about 330 deg. fahr., which represented a useful heat drop on the whole of the plant of 1810 deg. fahr. The gross efficiency of this plant was therefore approximately doubled, and the steam generation on the new conditions represented 100,000 lb. superheated 200 deg., as against the previous output of 60,000 lb. saturated. (*Iron and Coal Trades Review*, vol. 117, no. 3172, Dec. 14, 1928, p. 875, *d*)

Developments in Condenser Design in 1928

FOLLOWING the general trend of the past few years, condenser surface per unit of turbine capacity continues to decrease, and it is expected that a figure of 0.5 sq. ft. per kw. of capacity will be reached in the near future. This figure will be closely approached by the 90,000-sq. ft. condenser for the new 160,000-kw. East River unit. This is a ratio of 1 to 0.562. This reduction in area is noticeable in both one- and two-pass single and multiple shells. Limited space, improved water rates of turbines, and increases in the amount of bled steam are factors influencing this change.

One of the most interesting details of condenser design is the apparently successful use of condenser tubes rolled at both ends. Some condensers of this type are built with one movable tube sheet, but the Gould Street condensers, after elaborate and exhaustive experiments, were built with stationary tube sheets, all tube expansion being taken up by bending of the tubes.

Practically all auxiliaries are now motor-driven, using 440 or 2200 volts supplied either from transformers or shaft generators. A small number, especially industrial plants or those on the smaller systems, still feel that this practice is not absolutely dependable and use steam either normally or as standby. At Hudson Ave., auxiliaries are supplied from tertiary windings on the main transformers.

The Hell Gate condensers are of novel design. Each 160,000-kw. turbine will have a 137,500-sq. ft. condenser, each condenser being divided into halves placed end to end with a water box in

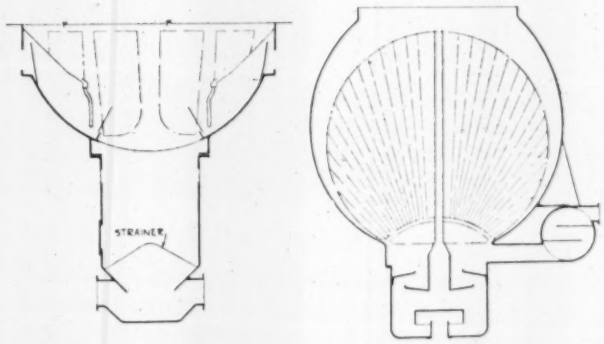


FIG. 7 ARRANGEMENT OF VERTICAL SINGLE-PASS CONDENSER FOR THE 104,000-KW. UNIT AT CRAWFORD AVE.

the center. Circulating water enters the bottom of the central water box through pipes under the basement floor. Since these are two-pass condensers, the discharge is from the top of the same box. Space limitations were such that the designs had to allow pulling the tubes from one section through the tube sheet of the other shell.

An external air cooler is provided, and air removal is taken care of by three-stage air ejectors. Motor-driven condensate and circulating-water pumps are used, the latter having a capacity of 100,000 g.p.m. at normal speed or 155,000 g.p.m. at full speed.

External air coolers were also used at Edgar with the new single-pass condenser. A somewhat more novel feature of this unit is the external hotwell which is connected to the condenser by pipes.

Another novel design is illustrated by the six 15,000-sq. ft. condensers serving the 104,000-kw. turbine at Crawford Ave. An attempt has been made to hide all circulating water piping as shown in Fig. 7. Water enters at the bottom of the condenser through a central conduit located within the tube nest, enters the top of the tubes, and flows forward. Air is removed at the side remote from the steam inlet, air-collecting ports being located around the central water conduit.

In this design the water flow is just opposite to that in the eight 22,000-sq. ft. condensers which will serve the 208,000-kw. State Line unit. In these eight condensers water enters the tube through the bottom, flows upward, and is discharged downward through passages cast integral with the shell.

In general, the use of single-pass condensers is increasing. This is particularly true of condensers which serve the larger units, the

greater part of the single-pass surface being installed on units of 50,000-kw. or over. This, it should be stated, is not due to any overwhelming superiority of the single-pass condenser, but rather to the flexibility of design and the ability to meet particular and limited space conditions, a prime requisite for the modern plant where the increasing size of units constantly presents new problems of design, construction, and installation. (*Power Plant Engineering*, vol. 32, no. 24, Dec. 15, 1928, pp. 1319–1321, 4 figs., *g*)

A Non-Condensable-Gas Eliminator

FOR 2 lb. excess pressure in the condenser, 1 per cent extra power is required to drive the compressor. Thus, if the correct condenser pressure is 150 lb. while the actual pressure, due to the presence of foreign gases, is 180 lb., then the excess

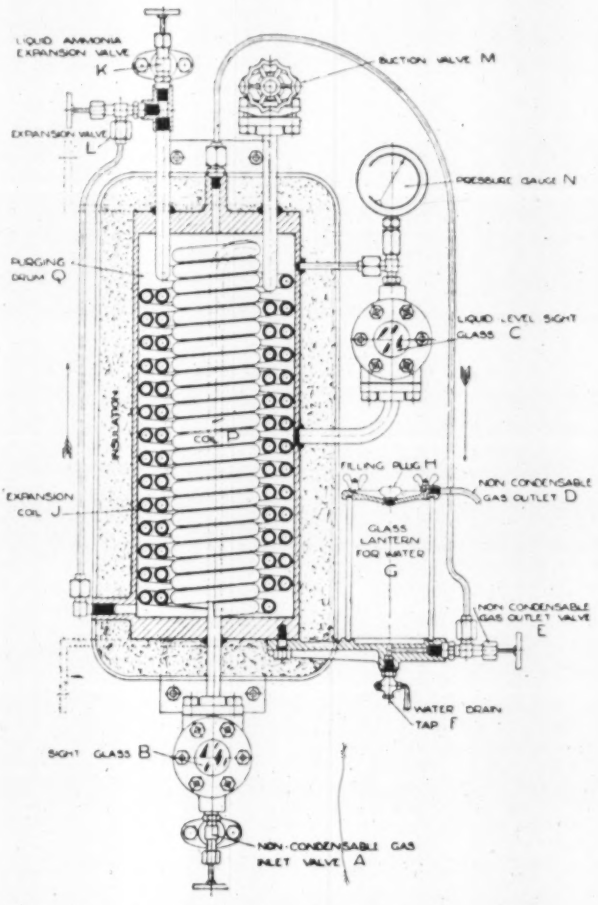


FIG. 8 A NON-CONDENSABLE-GAS ELIMINATOR

pressure is 30 lb., and therefore 15 per cent extra power is required to do the work. The presence of non-condensable gases increases the running cost in several other ways.

From this point of view the device shown in Fig. 8 is of interest as it is claimed to eliminate the non-condensable gases from the system without appreciable loss of ammonia. It is built by L. Sterne & Co., Ltd., Glasgow. The mixture of ammonia and non-condensable gases is introduced into the drum *Q* by the valve *A*, and as the drum is cooled by direct-expansion coils, the liquid ammonia condenses out and accumulates in the drum where it can be used to feed the expansion coil *J*, and the main liquid supply can be cut off at the expansion valve *K*. The non-condensable gases are now free to leave the system by the glass water lantern *G*, which absorbs what little ammonia is purged out with them. (*Cold Storage and Produce Review*, vol. 31, no. 368, Nov. 15, 1928, pp. 346, 1 fig., *d*)

SPECIAL PROCESSES

Cast-Iron Pipe Made Centrifugally in Sand Molds

DESCRIPTION of the methods used at the Gartshore-Thomson Pipe and Foundry Co., Hamilton, Ont., where pipe is made in sand-lined molds by the process developed by W. D. Moore, president of the American-Cast Iron Pipe Co., of Birmingham, Ala. In this process flasks are lined with sand by ramming. They are then transferred to a spinning bench where metal is supplied.

The casting operation is started by raising the machine hood and rolling into the machine in a horizontal position a flask containing a completed mold. The magnetic-clutch switch is closed and the driving motor started revolving at about 50 r.p.m. The ladle balance is adjusted for the weight of the pipe to be cast, and iron is poured into the ladle until the balance tips. The hood is then lowered, and in lowering it tips the ladle, pouring the iron through a spout into the slowly rotating mold. When the hood reaches its lowest position all the iron has been poured into the mold, and the driving motor is automatically and very rapidly accelerated to the full casting speed of about 900 r.p.m. The rapid acceleration results in the practically instantaneous development of centrifugal forces that throw the molten metal on the wall of the sand-lined mold, thus casting a pipe every part of which is formed at once. The machine is kept running at high speed until the iron has set. The motor is then stopped, the hood raised, and the flask containing the pipe is rolled out on the side opposite to that which it entered. Another empty flask is rolled in and the process repeated.

From the casting machines the flasks are rolled very slowly on a long horizontal runway to the stripper station. It takes about one hour for this operation, the object being to give the pipe ample time to cool before it is taken from the mold. At the stripper station the flasks are rolled, two at a time, on to a tilting table operated by a hydraulic cylinder.

The table is tilted to an angle of about 40 deg. to the horizontal, the bell end of the pipe being at the upper end. Below each flask and concentric with it in the tilted position is a long revolving steel tube with a hollow cutter on the end. These tubes are driven by electric motors through reduction gears, the whole apparatus being mounted on carriages that are operated on an inclined track by hydraulic cylinders.

On account of the great amount of dust created by the stripping operation it was necessary to close in the stripping station completely and carry the exhaust into a dust collector placed outside of the main building. It is claimed that by this process a pipe is produced having a tensile strength 38 per cent higher than pit-cast pipe. True gray-iron structure is produced with no sign of chill. (A. M. Buchanan, plant engineer, Gartshore Thomson Pipe and Foundry Co., in a paper for presentation at the Annual Meeting of the Engineering Institute of Canada, Hamilton, Ont., Feb. 13 to 15, 1929; published in *The Engineering Journal*, vol. 12, no. 1, Jan., 1929, pp. 13–15, 4 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

800-Lb. Hydraulic Cast-Iron Pipe Flanges and Flanged Fittings

IN THE Spring of 1920, the American Standards Association authorized the organization of a Sectional Committee on the Standardization of Pipe Flanges and Fittings for the purpose of unifying the standards for flanged and screwed fittings manufactured in this country. This Sectional Committee is sponsored by the Heating and Piping Contractors' National Association, the Manufacturers' Standardization Society of the Valves and Fittings Industry, and The American Society of Mechanical Engineers.

Early in 1928, Sub-Committee No. 1 undertook the revision of the standard dimensions for 800-Lb. Hydraulic Cast-Iron Pipe Flanges and Flanged Fittings which had been prepared by an A.S.M.E. committee and approved by the Council in December, 1918. After a thorough study of the earlier report and some revision, the Sub-Committee transmitted it to the Sectional Committee, who discussed the proposed American Standard at its October, 1928, meeting. The Committee finally approved the proposal by letter-ballot, with the recommendation that it be submitted to the three sponsor organizations for approval and transmission to the American Standards Association.

The A.S.M.E. Standardization Committee is therefore now called upon to make recommendations to the Council concerning this standard. Copies of this proposal are now available and may be obtained by addressing C. B. Le Page, Assistant Secretary, The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

Below are given the introductory notes and Tables 1 and 2 of the proposed Standard 800-Lb. Hydraulic Cast-Iron Pipe Flanges and Flanged Fittings. The tables which are omitted are entitled as follows: Table 3, Center-to-Contact-Surface Dimensions for Maximum Non-Shock-Working Hydraulic Pressure of 800 Lb. per Sq. In. at or near the Ordinary Range of Air Temperatures; and Table 4, Center-to-Flange-Edge Dimensions for Maximum Non-Shock Working Hydraulic Pressure of 800 Lb. per Sq. In. at or near the ordinary Range of Air Temperatures.

PROPOSED AMERICAN STANDARD

CAST-IRON PIPE FLANGES AND FLANGED FITTINGS

FOR MAXIMUM NON-SHOCK HYDRAULIC WORKING PRESSURE OF 800 LB. PER SQ. IN. (GAGE) AT OR NEAR THE ORDINARY RANGE OF AIR TEMPERATURES

INTRODUCTORY NOTES

1 *Sizes.* The sizes of the fittings in the following tables will be identified by the corresponding "nominal pipe size."

2 *Pressure Rating.* This standard shall be known as the "American 800-Lb. Hydraulic Cast-Iron Flange Standard," said pressure designation being the recommended rating at ordinary air temperatures.

3 *Marking.* All fittings must have marks cast on them indicating the manufacturer and the figures 800 indicating the maximum working hydraulic pressure for which the fittings are intended.

4 *Material.* The dimensional standards for cast-iron fittings covered herein are based on a high-grade product. The physical and chemical requirements of these flanges and fittings shall be in accordance with Table 1. These requirements are recommended, in the absence of similar data in the specifications of the A.S.T.M. applicable to cast iron intended for the manufacture of pipe flanges and fittings, pending the preparation of an acceptable specification.

TABLE 1 PHYSICAL AND CHEMICAL (CAST TEST BAR) REQUIREMENTS FOR CAST IRON FOR FLANGES AND FLANGED FITTINGS

Casting	Tensile strength, lb. per sq. in. minimum	Sulphur per cent, maximum
Light[1]	20,000	0.12
Medium[3]	21,000	0.12
Heavy[2]	24,000	0.12

[1] Light castings are those having any section less than 1/8 in. thickness.
[2] Heavy castings are those in which no section is less than 2 in. in thickness.
[3] Medium castings are those not included in either of the above classes.

800 Lb. Hydraulic Cast Iron Flanged Fittings

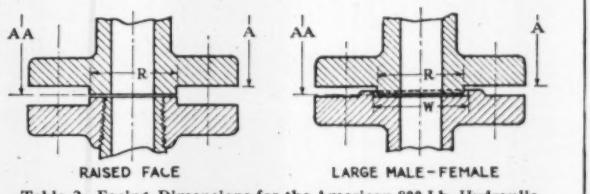


Table 2 Facing Dimensions for the American 800 Lb. Hydraulic Cast Iron Flanges

Nominal Pipe Size	Inside Diameter of Fitting	O.D. of Male[1] R	O.D. of Large Female W	Metal Thickness of Fitting Minimum	Outside Diameter of Flange	Thickness of Flange Minimum[1,2]	Diameter of Bolt Circle	Number of Bolts	Size of Bolts	Diameter of Bolt Holes
2	2	3 5/8	3 11/16	9/16	6 1/2	1 1/4	5	8	5/8	3/4
2 1/2	2 1/2	4 1/8	4 3/16	5/8	7 1/2	1 3/8	5 7/8	8	3/4	7/8
3	3	5	5 1/16	5/8	8 1/4	1 1/2	6 5/8	8	3/4	7/8
3 1/2	3 1/2	5 1/2	5 9/16	3/4	9	1 5/8	7 1/4	8	7/8	1
4	4	6 3/16	6 1/4	7/8	10 3/4	1 7/8	8 1/2	8	7/8	1
5	5	7 5/16	7 3/8	1 1/8	13	2 1/8	10 1/2	8	1	1 1/8
6	6	8 1/2	8 9/16	1 1/8	14	2 1/4	11 1/2	12	1	1 1/8
8	7 7/8	10 5/8	10 11/16	1 3/8	16 1/2	2 1/2	13 3/4	12	1 1/8	1 1/4
10	9 3/4	12 3/4	12 13/16	1 5/8	20	2 7/8	17	16	1 1/4	1 3/8
12	11 5/8	15	15 1/16	1 3/4	22	3	19 1/4	20	1 1/4	1 3/8

All dimensions given in inches.
[1] NOTE: A tolerance of plus or minus 0.016 inch (1/64 inch) is allowed on the inside and outside diameters of all facings.
[2] NOTE: The raised face of 1/16 inch is not included in the minimum thickness of flange.

October, 1928

5 *Facing.* All 800-lb. cast-iron flanges and flanged fittings shall have a 1/16-in. raised face not included in the flange thickness and of a diameter shown in Table 2. The illustrations above Table 2, show the application of raised face and male-female facings.

6 *Bolting.* Drilling templets are in multiples of four, so that fittings may be made to face in any quarter.

Bolt holes shall straddle the center line. All bolt holes shall be drilled 1/8 in. larger in diameter than the nominal size of the bolt.

Bolts may be of steel or wrought iron with standard "Rough Square Heads," with hexagon nuts.

7 *Spot Facing.* The bolt holes of 800-lb. cast-iron flanges and flanged fittings need not be spot faced, unless so ordered.

8 *Reducing Fittings.* All reducing fittings whether ells, tees, crosses, or reducers, and all double-branch and side-outlet fittings, shall have the same center-to-face and face-to-face dimensions throughout as for the largest opening.

9 *Elbows.* Special-degree elbows ranging from 1 to 45 deg., inclusive, have the same center-to-face dimension given for 45-deg. elbows, and those over 45 deg. and up to 90 deg., inclusive, shall have the same center-to-face dimensions given for 90-deg. elbows. The angle designation of an elbow is its deflection from straight-line flow and is the angle between the flange faces.

10 *Laterals.* The use of this type of fitting when made of cast iron is discouraged. Where necessary, use should be made of 600-lb. steel flanged laterals (B16e—1928), of which the flange dimensions and bolting are interchangeable with this standard.

Engineering and Industrial Standardization

Recent Developments

Screw Threads. The Society of Automotive Engineers and The American Society of Mechanical Engineers, as sponsors for the Sectional Committee on the Standardization and Unification of Screw Threads, under the procedure of the American Standards Association, are planning the reorganization of the Committee. When it was originally organized in 1920, the Committee consisted of 21 members representing the producer, the consumer, and general interests through four national engineering societies. The scope of the Committee's work was—

> "Nomenclature of screw threads; form of threads; diameters and pitches of screws for various sizes; classification of thread fits; tolerances and allowances for threaded parts; the gaging of threads; but not including threads for fire-hose couplings."

To date the Committee has restricted its activities practically to reviewing the report of the National Screw Thread Commission that was originally issued in 1921, and revised in 1924, and to preparing and issuing a similar report as an American Standard. Another revision of the N.S.T.C. report will be available soon in printed form, and it is felt by the sponsors and the members of the present Committee that the forthcoming report should be reviewed by the Sectional Committee after it has been reorganized to more completely represent the industrial interests.

Slotted-Head Proportions. The Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions has recently approved by letter ballot the June, 1928, draft of the proposed American Standard for Slotted-Head Proportions, with several reservations which were discussed at the meeting of the Committee held on October 23, 1928. This proposal goes to the two sponsor bodies as soon as an adjustment of the differences has been made.

Track Bolts. The suggestions received as a result of the wide distribution of the proposed American Standard for Track Bolts have been experimentally investigated by Sub-Committee No. 4 of the Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions in close cooperation with the Track Committee of the Engineering Division of the American Railway Association, and a revised proposal has been developed. Printer's-proof copies of this revised proposal are now available.

Pressure Piping. Preliminary drafts of the two sections of the proposed Code for Pressure Piping dealing with (*a*) Gas and Air Piping, and (*b*) Oil Piping, have been distributed recently in printer's-proof form for criticism and comment. Copies may still be obtained by addressing C. B. LePage, Assistant Secretary, A.S.M.E.

Pipe Flanges and Fittings. Two new Sub-Committees have been appointed by Chairman C. P. Bliss in compliance with actions taken at the recent meeting of the Sectional Committee on Pipe Flanges and Fittings.

Sub-Committee No. 7 is to undertake the Standardization of Rating of Pipe Fittings. This activity is to cover all the standards and proposed standards so far prepared by the Sectional Committee. Its immediate task, however, is a thorough study of the rating of the Tentative American Standard for Steel Pipe Flanges and Fittings published in June, 1927. H. C. Heaton is Temporary Chairman.

The Standardization of Marking of Pipe Fittings has been assigned to new Sub-Committee No. 8. The question of marking of pipe fittings to permit identification as American Standards in addition to those regularly employed by the manufacturer is one of long standing. This Sub-Committee is asked to formulate a simple method of designating the various standards developed by the Sectional Committee on Pipe Flanges and Fittings. W. S. Morrison is Temporary Chairman.

800-Lb. Hydraulic Cast-Iron Pipe Flanges and Flanged Fittings. The proposed American Standard for Cast-Iron Pipe Flanges and Flanged Fittings for Maximum Non-Shock Working Hydraulic Pressure of 800 Lb. per Sq. In. (gage) at Ordinary Air Temperatures has been completed by Sub-Committee No. 1 and approved by letter ballot of the Sectional Committee. It is accordingly now in the hands of the three sponsor bodies. An abstract of the proposal will be found on page 228 of this issue of MECHANICAL ENGINEERING.

Long Turn Sprinkler Fittings. Through complete cooperation between Sub-Committees No. 1 and 2 of the Sectional Committees on Pipe Flanges and Fittings and the N.F.P.A. Committee on Hydrants, Valves, and Pipe Fittings, this standard in revised form is now in the hands of the A.S.A. for approval.

Steel Companion Flanges. The proposed American Standard for Steel Companion Flanges for use at pressure of 250, 400, 600, and 900 lb. per sq. in. and at temperatures not exceeding 750 deg. fahr. has been released by Sub-Committee No. 3 of the Sectional Committee on the Standardization of Pipe Flanges and Fittings. This proposal is now in type, and printer's proofs have been distributed widely for criticism and comment. Copies may be obtained on application to the A.S.M.E.

Symbols for Heat and Thermodynamics. A completely revised draft of the proposed letter symbols for Heat and Thermodynamics has been prepared by Chairman S. A. Moss since the Committe met on October 5, 1928. It will be recalled that this proposal was generally distributed for criticism and comment in October, 1927. The report is now in the hands of the Sectional Committee for approval by letter ballot.

Aeronautical Symbols. The proposed set of letter symbols for aeronautics prepared by Sub-Committee No. 5 has been published in the technical publications and distributed for general criticism. The Committee considered the comments, and on the approval of the five sponsor societies the proposal was submitted to the A.S.A. in November, 1928, with the request that these symbols be approved as an American Tentative Standard. This approval was received on February 5.

Symbols for Hydraulics. The proposed letter symbols for hydraulics, prepared by Sub-Committee No. 2 have been sent to the technical press and generally distributed for comment. The Committee then submitted these symbols to the sponsors, who are now voting on their recommendation to the A.S.A. Favorable actions have been taken by four of them.

Symbols for Electrical Quantities. This set of letter symbols is the first of a group of electrical symbols to be prepared by Sub-Committee No. 7 on Electrotechnical Symbols, including Radio. These letter symbols, after being widely distributed for review and approved by the sponsors, were presented to the A.S.A. in November, 1928. The letter ballot of the latter was completed on February 5, approving the standard.

Abbreviations for Scientific and Engineering Terms. This set of symbols developed by Sub-Committee No. 9 has just been revised by the Committee on the basis of comments received from the general distribution of the proposal in proof form in September, 1928. The revised report is now in the hands of the Sectional Committee for approval by letter ballot.

Transmission Chains and Sprockets. Meetings of the Sub-Committee on Roller Chains, the Sub-Committee on Silent Chains, and the Sectional Committee on Roller Chains and Sprockets were held in New York on January 8, 1929. The first-named Sub-Committee devoted considerable time to reviewing and revising the draft of the report it had prepared in Buffalo in October. At the meeting of the Sub-Committee on Silent Chains the possibility of standardizing this type of transmission was discussed in a general way, and it was agreed that the sprocket wheel was the logical starting point. The setting up of standards for pitch, width, tool angle, tangency radius, height of teeth above chord lines, and distance to bottom of teeth seemed to be possible.

Engineering and Scientific Graphs. Sub-Committee No. 6 of the Sectional Committee on Graphical Presentation held a meeting in New York in December at which the details of the four following proposals were worked out: I, Functions of Graphical Methods; II, Details to Be Considered in Constructing Any Chart; III, Functional Relationship between Two Variables; and IV, Frequency Distributions.

In cooperation with the sponsor society this Sub-Committee is developing a program for a symposium on this subject. The brief papers to be presented on this occasion will cover the several phases of the subject included within the titles of the four proposals listed above. The Committee plans to select speakers who are acknowledged authorities in their respective fields and fully acquainted with the latest modern developments in graphical methods.

The papers will give particular attention to the principles underlying the construction and application of graphical charts, and provide sufficient illustrations to make the principles clear to the average engineer. It is the idea of the Committee that the series of papers, together with the discussions, would be edited and published as a report of the symposium. In this they would present the very latest and best summary of the theory and application of graphical methods. This report would then be made the basis of many of the Committee's detailed suggestions for graphical standards.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of January 15–February 15, 1929:

Cotton Rubber-Lined Fire Hose. (American Tentative Standard.)

Sponsored by the American Society for Testing Materials and the Fire-Protective Group. Published by the A.S.T.M.

Standard Method of Test for Penetration of Bituminous Materials (American Tentative Standard.)

Standard Method of Float Test for Bituminous Materials. (American Tentative Standard.)

Standard Method of Test for the Determination of Bitumen. (American Tentative Standard.)

All three sponsored by the American Society for Testing Materials. Published by the A.S.T.M.

Specifications for Materials for Use in the Manufacture of Special Track Work. (American Tentative Standard.)

Sponsored by the American Electric Railway Association. Published by the A.E.R.A.

Tinners', Coopers', and Belt Rivets. (American Standard.)

Sponsored by the Society of Automotive Engineers and The American Society of Mechanical Engineers. Published by the A.S.M.E.

Specifications for Hard-Drawn Copper Wire. (American Standard.)

Sponsored by the American Society for Testing Materials. Published by the A.S.T.M.

N.E.M.A. Submits Three Standards

THE American Standards Association has received a communication from the National Electrical Manufacturers, Association requesting the organization of three sectional committees under its procedure to develop comprehensive American Standards for:

a Electrical attachment plugs and attachment-plug receptacles, definitions, types, their selection and application, and their design, construction, performance, and test

b Electrical lamp receptacles and sockets, definitions, types, their selection and application, and their design, construction, performance, and test

c Electrical snap switches, definitions, types, their selection and application, and their design, construction, performance, and test.

The N.E.M.A. points out that it has evolved standards for all three of these products and desires that they be considered by the Sectional Committees when formed. It also offers its services to the A.S.A. as sponsor for these three Sectional Committees.

American Legion Plans Campaign for Safety on Streets

IT IS REPORTED in *Public Safety* that the American Legion is the latest national organization to plan a definite educational safety program. The following resolution was passed at the tenth annual national convention of the Legion, held recently at San Antonio, Texas.

WHEREAS, The great and rapidly increasing accidents and fatalities of our children on highways, on account of carelessness, is greatly deplored; and

WHEREAS, The American Legion is vitally interested in the care and protection of life; be it

Resolved, That the American Commission formulate a definite educational "Safety First" program for the consideration and action of all departments.

When the three-quarters of a million men, in 11,000 active posts in the country, are once imbued with the principles of safety, another mighty force in accident prevention will be at work.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,	*J. L. WALSH,*
Aeronautic Division	*National Defense Division*
A. L. KIMBALL, JR.,	*L. H. MORRISON,*
Applied Mechanics Division	*Oil and Gas Power Division*
H. W. BROOKS,	*W. R. ECKERT,*
Fuels Division	*Petroleum Division*
R. L. DAUGHERTY,	*F. M. GIBSON and W. M. KEENAN,*
Hydraulic Division	*Power Division*
WM. W. MACON,	*WINFIELD S. HUSON,*
Iron and Steel Division	*Printing Industries Division*
JAMES A. HALL,	*MARION B. RICHARDSON,*
Machine-Shop Practice Division	*Railroad Division*
CHARLES W. BEESE,	*JAMES W. COX, JR.*
Management Division	*Textile Division*
G. E. HAGEMANN,	*WM. BRAID WHITE,*
Materials Handling Division	*Wood Industries Division*

Applied Mechanics

Gas Discharge Through Orifices

AM-2 Two vessels of equal volume, A and B, are filled with gas of known chemical composition. The pressures in A and B are equal, and the common pressure is greater than standard atmospheric pressure. The density of the gas in A is different from that of the gas in B. Each vessel is discharging gas through an orifice into standard atmosphere. The orifices are so constructed that their areas and coefficients of discharge are equal. The areas of the orifices are such that the pressure in the main vessel will not be appreciably affected by the gas discharged in a unit time increment. What is the relation of the volume discharged from A to the volume discharged from B expressed as the ratio of the density of the gas in A to the density of the gas in B?

(*a*) Since the orifices and discharge coefficients are equal, the pressures are equal and constant for a given time interval, and both vessels are discharging into a common atmosphere; the only variables encountered in a given time interval are the densities of the gases and the comparative volumes discharged.

The only course of energy that may be called upon to move the gases is that energy represented by the compression of the gases to a pressure above atmospheric; this energy may be made available for motion of the gases when they are permitted to expand freely through the orifices into the region of lower pressure.

The pressure energy thus released appears as kinetic energy in the gas stream issuing from each of the orifices, and the energy is directly proportional to the volume of the gas permitted to expand from pressure No. 1 to pressure No. 2. No account is taken in this answer of the practical difficulties that one encounters in temperature changes during the expansion of the gases through an orifice, nor is any account taken of the possible change in orifice dimensions due to the condensation of moisture deposited during the temperature reduction. May we not assume these possible variables to be non-existent, or equal in all of our tests, so that they need not further complicate the answer?

Getting back to a solution on an energy basis, let us establish a nomenclature and deal with symbols from this point on.

D_a = density of gas in vessel A
D_b = density of gas in vessel B
V_a = velocity of gas discharged from vessel A
V_b = velocity of gas discharged from vessel B
P_a = pressure of gas in vessel A = P_1
P_b = pressure of gas in vessel B = P_2
P_2 = pressure of a standard atmosphere.

When two equal volumes of gases are expanded through an orifice from their original pressure (P_1) to a new pressure (P_2), their expanded volumes are also equal and the amount of energy released is identical in each of the two cases, and is absolutely independent of the density of the gases. Gas density does, however, affect the velocity of the issuing gas stream and hence affects the time of discharge for a given original volume.

The total energy released during the expansion appears as kinetic energy in the gas stream and is stated as

$$\text{Energy} = \frac{\text{Mass} \times (\text{Velocity})^2}{2g} = \frac{MV^2}{2g}$$

In the case we have set up for ourselves we may equate the amounts of energy released from two equal original volumes expanding from P_1 to P_2; therefore

$$\frac{M_a V_a^2}{2g} = \frac{M_b V_b^2}{2g}$$

= energy released that reappears as kinetic energy.

The time of discharge will not be identical in each of these cases.

Substituting for mass (M) we may use gas density (D) times a constant (C) which we need not bother to evaluate, and we have

$$\frac{CD_a V_a^2}{2g} = \frac{CD_b V_b^2}{2g}$$

simplifying, this equation takes the form

$$D_a V_a^2 = D_b V_b^2$$

$$\frac{D_a}{D_b} = \frac{(V_b)^2}{(V_a)^2} \quad \text{or} \quad \frac{V_b}{V_a} = \sqrt{\frac{D_a}{D_b}}$$

The volume of gas discharged in a given time is directly proportional to the velocity of discharge. So substituting volume terms for velocity terms in the previous equation we find that

$$\frac{\text{Volume } B}{\text{Volume } A} = \frac{\text{Density } A}{\text{Density } B}$$

In a given time, identical orifices will discharge volumes of gases from a region at pressure P_1 to a region at pressure P_2 that are inversely proportional to the square roots of the densities of the gases. (Albert W. Black, Department of Research, St. Louis Public Service Company, St. Louis, Mo.)

(*b*) The relation of the volume from tank *B* to the volume from tank *A* will be:

$$\text{Vol. } B = \text{Vol. } A \sqrt{\frac{\text{density of gas in tank } B}{\text{density of gas in tank } A}}$$

This is assuming that the temperatures of both gases are equal. (J. M. Augustus, Fuel Engineer, The Pure Oil Co., Chicago, Ill.)

Fuels

BOILER-SETTING HEIGHTS

F-5 What should be the heights from grate to shell of 100-, 125-, 150-, and 200-hp. h.r.t. boilers for the highest efficiencies, using West Kentucky or Tennessee coal running about 40 per cent volatile and 10 per cent ash at 100 to 125 per cent of rating, hand fired? What would be the heights at 125 to 150 per cent of rating under the same conditions?

(*a*) For 100-hp. boilers operating at 100 to 125 per cent of rating, hand fired, the writer recommends that 36 in. be provided between the grate and the shell. Boilers of 125, 150, and 200 hp. operating at the same ratings require 42 in.; operating at 125 to 150 per cent of rating, 42 in. is recommended for the 100-hp. boiler and 48 in. for the 125-, 150-, and 200-hp. boilers. (W. P. Smith, Superintendent, Frost Manufacturing Company, Galesburg, Ill.)

(*b*) The height from grate to shell of 100-hp. h.r.t. boilers under the conditions outlined in this question should be 36 in.; for the 125- and 150-hp. units 42 in. should be provided. The 200-hp. boiler will operate best with a height of 48 in. The same boilers operating at 125 to 150 per cent of rating under the same conditions require heights 6 in. greater for each of the sizes mentioned above. (A. W. Harris, Sales Manager, The Casey-Hedges Company, Chattanooga, Tenn.)

Wood Industries

HOLDING POWER OF WOOD SCREWS

WI-2 Is there any information on the holding power of wood screws later than that given in Marks' "Mechanical Engineers' Handbook," Third Edition?

Information on this subject, taken from Technological Paper of the U. S. Bureau of Standards No. 319, by I. J. Fairchild, July 17, 1926, was published in the Conference Table Section of the November, 1927, issue of MECHANICAL ENGINEERING. Additional information in the form of a German paper has been discovered in the Engineering Societies Library, and a brief abstract of the results is given below to supplement that published in the November, 1927, issue. This treatment, which appears in *Werkstattstechnik*, 1927, Heft 12, under the title "Die Haftkraft der Holzgewindeschrauben," gives a general formula for calculating the holding power of screws, several diagrams, and a series of tables for various woods. Only the formula and a summary of the tabular results appear in this account of the report.

The general formula is

$$H = (a\,s\,D + b)P$$

where

H = holding power in kg. per 100 mm. of thread
s = specific weight of wood in kg. per sq. dm.
D = diameter of screw in mm.
P = compressive strength of wood, kg. per sq. cm.
a,b = constants depending on kind and strength of wood.

The following tabulation of values will prove helpful when employing the formula.

	s	P	a	b	
Oak	0.825	605	0.32	1.35	
Fir	0.439	390	0.52	1.36	Average value
Larch	0.598	565	0.24	1.68	of constants:
Teak	0.602	540	0.45	1.48	$a = 0.38$
Elm	0.840	670	0.26	1.49	$b = 1.55$
Ash	0.723	530	0.41	1.58	
Red beech	0.810	660	0.45	1.88	

A summary of the tables giving the holding power of various sizes of screws in various woods follows.

Diameter of screw in mm.	Average holding power across fiber, kg. per 100 mm. of thread					
	Oak	Fir	Larch	Teak	Elm	Ash
7	1910	1166	1606	2048	1989	1863
8	2075	1233	1676	2302	2128	2091
9	2366	1342	1794	2380	2268	2190
10	2320	1380	1725	2275	2285	2330
11	2651	1567	2050	2865	2640	2288
12	2554	1672	2059	2824	2819	2757
13	2748	1716	2128	3079	2904	2874
14	3058	1744	2271	3355	3188	2955
15	3052	1853	2360	3306	3393	3222
16	3341	2033	2434	3499	3430	3423
17	3321	2126	2364	3396	3357	3420
19	4006	2159	2556	3900	3845	3553
25	..	..	..	..	4300	..

Questions to Which Answers Are Solicited

ACID-EROSION INHIBITION

F-6 In unlined steel stacks, flues, and breachings operating up to capacity, what methods have been used to inhibit acid erosion where high-sulphur coals are burned, and what results in increased life have been attained?

COAL FOR FORCED-DRAFT AND PREHEAT CONDITIONS

F-7 What coal specifications are recommended for forced-draft conditions such as are encountered in Taylor stokers operating on 400-deg. preheated air?

DUST-COLLECTING SYSTEMS

MH-2 Centrifugal separators are being considered for installation in a dust-collecting system. Possible arrangements involve the use of one oversize separator or two small ones placed in tandem. Which arrangement is considered the better, and why?

DEFORMATION OF ALUMINUM SHEET

AM-3 A 41-in. by 54-in. by 0.029 in.-thick aluminum sheet is bent around a 24-in.-diameter roll, the 41-in. dimension passing around the cylinder. What is the effect on each of the two surfaces of the plate, and how much does each change from its original dimension?

BENDING A HEAVY I-BEAM

M-3 It is proposed to bend a 9-in. I-beam of heavy section to a radius of 11 ft., 3 in. What methods are recommended to accomplish this without destroying the shape of the web of the beam?

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

During the past two years the Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

Specifications for Alloy-Steel Bolting Material for High-Temperature Service and Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service

The following new specifications have been approved for incorporation in the Boiler Code:

SPECIFICATIONS FOR ALLOY-STEEL BOLTING MATERIAL FOR HIGH-TEMPERATURE SERVICE[1]

S-286. *Scope.* *a* These specifications cover alloy-steel bolting material for valves, flanges and fittings for high-temperature service (Note 1). The term "bolting material" as used in these specifications covers rolled, forged, or cold-drawn bars, and bolts, screws, and studs.

b Three classes of material are covered, A, B, and C, classified in accordance with their physical properties as specified in Par. S-294.

c Nickel chrome-nickel, chrome-vanadium, chrome-manganese, or any other types of alloy steel approved by the purchaser may be submitted under these specifications.

d Carbon-steel nuts and washers for use with this bolting material are covered in Par. S-300.

S-287. *Basis of Purchase.* When agreed upon between the manufacturer and the purchaser, Brinell hardness tests may be made to determine the acceptance of bolting material in lieu of the tension tests herein specified; but shall not be used as a basis for rejection without confirming tension tests being made.

S-288. *Certification of Test for Bolts, Screws, and Studs.* Unless otherwise specified on the order, a certification that bolts, screws, and studs for valves, and other fittings intended for stock and other purposes requiring assembly in the manufacturer's plant conform to the requirements of these specifications, shall be accepted in lieu of the tests herein specified.

S-289. *Process.* The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, or crucible.

S-290. *Discard.* A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

S-291. *Heat Treatment.* *a* Heat treatment shall consist of quenching and tempering.

b Immediately after rolling or forging, the bolting material shall be allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling. For quenching and tempering, the material shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a "quenching charge") and quenched in some medium under substantially uniform conditions for each quenching charge. The material shall then be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a "tempering charge"), and allowed to cool uniformly.

S-292. *Chemical Composition.* *a* The steel shall conform to the following requirements as to chemical composition:

Phosphorus, per cent	not over 0.045
Sulphur, per cent	not over 0.05

b The composition of the steel furnished under these specifications, other than phosphorus and sulphur, shall be agreed upon by the manufacturer and the purchaser (Note 2).

S-293. *Check Analyses.* Analyses may be made by the purchaser from samples representing the bolting material. The chemical composition thus determined shall conform to the requirements specified in Par. S-292.

S-294. *Tension Tests.* *a* The bolting material, after final heat treatment, shall conform to the following requirements as to minimum tensile properties:

	Class A	Class B	Class C
Tensile strength, lb. per sq. in.	95,000	105,000	125,000
Yield point, lb. per sq. in.	70,000	80,000	105,000
Elongation in 2 in., per cent	20	20	16
Reduction of area, per cent	50	50	50

b The yield point shall be determined by the drop of the beam of the testing machine or by the use of dividers.

S-295. *Brinell Hardness Tests.* *a* When Brinell hardness tests are made, the bolting material, after final heat treatment, shall conform to the following requirements:

	Brinell hardness number
Class A	190–250
Class B	210–270
Class C	260–320

b The Brinell hardness test shall be made in accordance with the Standard Methods of Brinell Hardness Testing of Metallic Materials (Serial Designation: E 10) of the American Society for Testing Materials.

S-296. *Tension-Test Specimens.* *a* The tension-test specimens taken from the bolting material shall conform to the dimensions shown in Fig. S-11, except as specified in Par. *b*. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

[1] Identical With A.S.T.M. Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A96–27).

b In the case of small sections which will not permit of taking the standard tension-test specimen specified in Par. *a*, the tension-test specimen shall be as large as feasible and its dimensions shall be proportional to those shown in Fig. S-11. The gage length for measuring elongation shall be four times the diameter of the specimen.

S-297. *Number of Tests.* *a* Except as specified in Par. *b*, one tension test shall be made for each lot of 100 pieces or less of bolting material from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension test shall be made from each lot of 100 pieces or less from each quenching charge. If more than one melt is represented in a quenching charge, one tension test shall be made from each lot of 100 pieces or less from each melt.

b Unless required on the order, tension tests shall not be made on an order of less than 100 bolts, screws, or studs; in which case acceptance shall be based upon the provision in Par. S-287 or S-288.

c If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

d If the percentage of elongation of any test specimen is less than that specified in Par. S-294 *a* and any part of the fracture is outside of the middle three-fourths of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

S-298. *Retests.* If the results of the physical tests of any lot of bolting material do not conform to the requirements specified, the manufacturer may retreat such lot one or more times and retests shall be made as specified in Par. S-297 *a*.

S-299. *Finish.* The bolting material shall be free from injurious defects and shall have a workmanlike finish.

S-300. *Nuts and Washers.* Bolts and studs shall be equipped with semi-finished carbon-steel nuts of U. S. Standard rough dimensions, chamfered and trimmed. If washers are used under nuts they shall be of forged or rolled steel. All nuts and washers shall be free from injurious defects and shall have a workmanlike finish. Nuts shall conform to the chemical requirements for phosphorus and sulphur as follows:

	Class A	Class B
Phosphorus, per cent, not over	0.045	0.05
Sulphur, per cent, not over	0.05	0.15

S-301. *Threads.* U. S. Standard threads shall be used, except that no stud shall have less than eight threads per inch.

S-302. *Identification Marks.* Identification marks to be stamped on bolting material shall be agreed upon between the manufacturer and the purchaser.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures up to 750 deg. fahr. (400 deg. cent.); or, at the discretion of the designing engineer, higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the sponsorship of the Heating and Piping Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry and The American Society of Mechanical Engineers, and organized under the procedure of the American Standards Association.

NOTE 2.—It is recommended that the carbon content shall not be less than 0.20 nor more than 0.45 per cent, and that the carbon range shall be 0.10 per cent of carbon.

SPECIFICATIONS FOR FORGED OR ROLLED STEEL PIPE FLANGES FOR HIGH-TEMPERATURE SERVICE[2]

S-303. *Scope.* *a* These specifications cover forged or rolled steel flanges to be attached to piping for high-temperature service (Note 1).

[2] Identical with A.S.T.M. Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A105–28).

b Three classes of material are covered, designated Class A, B, and C, respectively. Class A is intended for forge welding and is classified by the chemical properties as specified in Par. S-308 *a* and *b*, and by the physical properties as specified in Par. S-310 *a*. Classes B and C are classified in accordance with their physical properties as specified in Par. S-310 *a*.

S-304. *Certification of Test.* Unless otherwise specified on the order, a certification that the material conforms to the requirements of these specifications shall be the basis of acceptance of the material.

S-305. *Process.* The steel may be made by either or both of the following processes: open-hearth or electric furnace.

S-306. *Discard.* A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

S-307. *Heat Treatment.* *a* Class A steel does not require heat treatment (Note 2).

b Classes B and C steels shall be heat treated. Heat treatment may consist of annealing or normalizing.

c *Annealing.* The procedure for annealing shall consist in allowing the flanges, immediately after forging or rolling, to cool to a temperature below the critical range, under suitable conditions to prevent injuries by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an "annealing charge") and allowed to cool uniformly in the furnace.

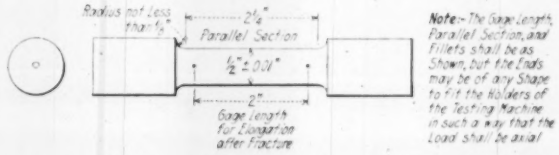

Radius not Less than 1/4"
2 1/4"
Parallel Section
1/2" ± .001"
2"
Gage Length for Elongation after Fracture
Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a way that the Load shall be axial

FIG. S-11

d *Normalizing.* The procedure for normalizing shall consist in allowing the flanges, immediately after forging or rolling, to cool to a temperature below the critical range, under suitable conditions to prevent injuries by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a "normalizing charge"), and allowed to cool in still air.

e No flanges which have been quenched in any liquid medium shall be offered under these specifications.

S-308. *Chemical Composition.* *a* The steel shall conform to the following requirements as to chemical composition:

	Class A	Classes B and C
Manganese, per cent	0.35–0.60	0.40–0.80
Phosphorus, per cent	Not over 0.05	Not over 0.05
Sulphur, per cent	Not over 0.05	Not over 0.05
Silicon, per cent	Not over 0.40	.....

b The carbon content of Class A material shall not exceed 0.20 per cent. The carbon content of Class B and C material shall be a matter of agreement between the purchaser and the manufacturer.

S-309. *Check Analysis.* *a* An analysis may be made by the purchaser from one forged or rolled flange representing each melt. The chemical composition thus determined shall conform to the requirements specified in Par. S-308, except that phosphorus and sulphur may not exceed 0.055 per cent.

b All drillings for analysis shall be taken at least 1/4 in. below the surface, or turnings may be taken from test specimens.

S-310. *Tension Tests.* *a* Forged or rolled steel flanges shall conform to the following minimum requirements as to tensile properties:

	Flanges for forge welding Class A	Flanges not for forge welding Class B	Class C
Tensile strength, lb. per sq. in..	54,000	60,000	70,000
Yield point, lb. per sq. in.....	30,000	30,000	36,000
Elongation in 2 in., per cent....	25.0	25.0	22.0
Reduction of area, per cent.....	38.0	38.0	30.0

b The yield point shall be determined by the drop of the beam of the testing machine, or by dividers, at a speed of head of the testing machine not to exceed $^1/_8$ in. per minute. The tensile strength shall be determined at a speed of head not to exceed $1^1/_2$ in. per minute.

S-311. *Number of Tests.* *a* One tension test shall be made from each melt or for each annealing or normalizing charge. If more than one melt is represented in any annealing or normalizing charge, a test shall be made from each melt.

b If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

c If the percentage of elongation of any test specimen is less than that specified in Par. S-310 *a* and any part of the fracture is more than $^3/_4$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

d For purposes of testing, the necessary extra flanges shall be provided to furnish the specimens required in Par. *a*. The test specimen shall be cut tangentially from the flange portion approximately midway between the inner and outer surfaces and approximately midway between the front and back faces.

S-312. *Tension-Test Specimens.* *a* The tension-test specimens taken from the flanges shall conform to the dimensions shown in Fig. S-11, except as specified in Par. *b*. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

b In the case of small sections which will not permit of taking the standard test specimen specified in Par. *a*, the tension-test specimen shall be as large as feasible and its dimensions shall be proportional to those shown in Fig. S-11. The gage length for measuring elongation shall be four times the diameter of the specimen.

S-313. *Retests.* If any of the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retreat such lots one or more times and retests shall be made as specified in Par. S-311 *a*.

S-314. *Workmanship.* *a* The flanges shall conform to the sizes and shapes specified by the purchaser.

b The flanges shall be free from injurious defects and shall have a workmanlike finish.

S-315 *Identification.* Identification marks shall be stamped legibly on each flange.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures up to 750 deg. fahr. (400 deg. cent.), or at the discretion of the designing engineer, higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the sponsorship of the Heating and Piping Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry, and The American Society of Mechanical Engineers, and organized under the procedure of the American Standards Association.

NOTE 2.—It is recommended that Class A flanges and pipe be annealed or normalized following the forge-welding operation.

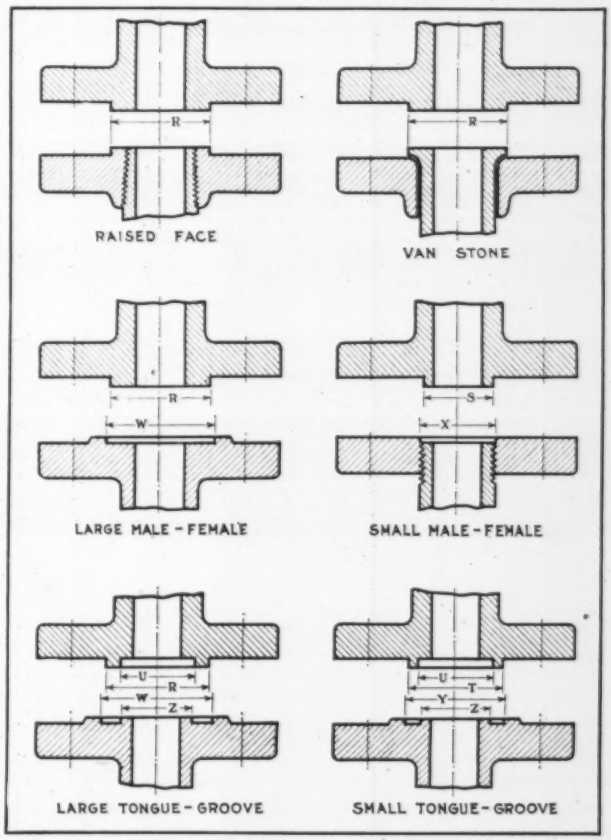
New Standard for Pipe Flanges

IN ACCORDANCE with an announcement in the January, 1928, issue of MECHANICAL ENGINEERING, in which it was stated that the Boiler Code Committee had under consideration the adoption of the New American Standard for Pipe Flanges and Flanged Fittings, comments and criticisms thereon have been received and very carefully considered by the Committee. As a result, the Committee has decided to revise Tables A-5 and A-6 as they have appeared in former editions of the Code and to make additions thereto which will correspond with the New Tentative American Standard for Steel Pipe Flanges and Flanged Fittings. On account of the limited space available in the Boiler Code for inclusion of these standards, it has been found necessary to limit the matter to be incorporated therefrom in the Boiler Code to facing dimensions and other general dimensional data pertaining to the flanges only. Accordingly, there is reproduced herewith the table of facing dimensions for five different pressure limits for flanges and two tables covering general dimensions of steel and cast-iron fittings for different pressure limits. Attention is called by the Boiler Code Committee to the fact that while in the New Tentative American Standard, the $4^1/_2$- and 7-in. pipe sizes have been omitted, they are included in the following tables as special sizes. This is in response to the requests that have been received for an inclusion of information pertaining to these particular sizes which are in extensive use in connection with boiler construction and erection.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PAR. P-277 REVISED:

P-277. The safety valve or valves shall be connected to the boiler independent of any other steam connection, and attached as close as possible to the boiler, without any unnecessary inter-



STEEL FLANGED FITTINGS

The following table is taken from publication (B16*a*-1927) of standards developed by the Sectional Committee on Pipe Flanges and Fittings which has received the approval of the M.S.S.A.F.I., H.P.C.N.A., A.S.M.E. and the American Standards Association.

TABLE A-5*a*. FACING DIMENSIONS FOR THE AMERICAN 250, 400, 600, 900, AND 1350 LB. STEEL FLANGES

Nominal Pipe Size In.	Outside Diameter[3]			I. D. of Large and Small Tongue[3, 5] In.	Outside Diameter[3]			I. D. of Large and Small Groove[3, 5] In.
	Raised Face, VanStone Large Male, and Large Tongue[5] In.	Small Male[4, 5] In.	Small Tongue[5] In.		Large Female and Large Groove[5] In.	Small Female[4, 5] In.	Small Groove[5] In.	
	R	S	T	U	W	X	Y	Z
½	1⅜	⅝	1⅜	1	1 1/16	⅝	1 1/16	⅝
¾	1⅝	⅞	1⅝	1 1/16	1¾	1	1¾	1 1/16
1	2	1 1/16	1⅞	1⅜	2 1/16	1¼	1⅛	1 1/16
1¼	2½	1⅜	2¼	1⅞	2⅜	1⅝	2 1/16	1⅛
1½	2⅞	1¾	2½	2⅛	2⅝	1⅞	2⅜	2 1/16
2	3⅜	2 1/16	3 1/16	2⅞	3⅛	2 1/16	3 1/16	2⅛
2½	4⅛	2⅛	3¾	3⅜	4 1/16	2¾	3⅛	3 1/16
3	5	3 1/16	4⅝	4 1/16	5 1/16	3⅜	4⅛	4 1/16
3½	5½	3⅛	5⅛	4¾	5 1/16	3⅞	5 1/16	4⅛
4	6 1/16	4 1/16	5⅛	5 1/16	6¼	4⅜	5¾	5 1/16
5	7 1/16	5⅜	6⅛	6 1/16	7⅜	5 1/16	6⅞	6¼
6	8½	6⅜	8	7½	8 1/16	6 1/16	8 1/16	7 1/16
8	10⅝	8⅜	10	9⅜	10⅛	8 1/16	10⅛	9 1/16
10	12¾	10½	12	11¼	12⅛	10 1/16	12⅛	11 1/16
12	15	12½	14¼	13½	15 1/16	12 1/16	14 1/16	13 1/16
14 O.D.	16¼	13¾	15½	14¾	16 1/16	13⅛	15 1/16	14⅛
16 O.D.	18½	15¾	17⅝	16¾	18 1/16	15⅛	17⅛	16⅛
18 O.D.	21	17¾	20⅛	19¼	21 1/16	17⅛	20 1/16	19 1/16
20 O.D.	23	19¾	22	21	23 1/16	19⅛	22 1/16	20⅛
24 O.D.	27¼	23¾	26¼	25¼	27 1/16	23⅛	26 1/16	25 1/16
SPECIAL SIZES (USE NOT RECOMMENDED)								
4½	6¾	4⅛	6¼	5¾	6⅛	4⅞	6 1/16	5⅛
7	9⅝	7⅜	9	8⅜	9⅛	7 1/16	9⅛	8 1/16

Height, Raised Face, 250 Lb. Std.[1]..... 1/16 in.
Height, Raised Face, Large and Small Male and Tongue, 400, 600, 900, and 1350 Lb. Stds.[2]..... ¼ in.
Depth of Groove or Female Companion Flanges..... 1/16 in.

[1] NOTE—Regular facing for 250 lb. flange standard is a 1/16 in. raised face included in the minimum flange thickness dimensions given in Table A-5*b*. A 1/16 in. raised face is also permitted on the 400, 600, 900 and 1350 lb. flange standards, but it must be added to the minimum flange thicknesses.

[2] NOTE—Regular facing for 400, 600, 900, and 1350 lb. flange standards is a ¼ in. raised face, not included in minimum flange thickness dimensions given in Table A-5*b*.

[3] NOTE—A tolerance of plus or minus 0.016 in. (1/64 in.) is allowed on the inside and outside diameters of all facings.

[4] NOTE—Care should be taken in the use of joints of these dimensions, as they apply particularly on lines where the joint is made on the end of pipe, to insure that pipe used is thick enough to permit sufficient bearing surface to prevent crushing the gasket.

[5] NOTE—Gaskets for male-female and tongue-groove joints shall cover the bottom of the recess with minimum clearances taking into account the tolerances prescribed in Note. 3.

CAST IRON FLANGED FITTINGS

TABLE A-6*b*. DIMENSIONS OF 250 LB. CAST-IRON FLANGES

The following table is taken from publication (B16*b*-1928) of standards developed by the Sectional Committee on Pipe Flanges and Fittings which has received the approval of the M.S.S.A.F.I., H.P.C.N.A., A.S.M.E. and the American Standards Association.

Nominal Pipe Size In.	Outside Diameter of Flange In.	Thickness of Flange Minimum[3, 4] In.	Diameter of Raised Face In.	Diameter of Bolt Circle In.	Number of Bolts[1] In.	Diameter of Bolts In.	Diameter of Drilled Bolt Holes[1] In.	Total Effective Area Bolt Metal In.	Stress, Lb. per Sq. In. Bolt Metal[3] In.
1	4⅞	⅞	2⅛	3½	4	⅝	¾	0.808	970
1¼	5¼	¾	3⅛	3⅞	4	⅝	¾	0.808	1520
1½	6⅛	1 1/16	3⅝	4½	4	¾	⅞	1.208	1345
2	6½	⅞	4 1/16	5	8	⅝	¾	1.616	1595
2½	7½	1	5⅛	5⅞	8	¾	⅞	2.416	2090
3	8¼	1⅛	5⅝	6⅝	8	¾	⅞	2.416	2030
3½	9	1 1/16	6 1/16	7¼	8	¾	⅞	2.416	2460
4	10	1¼	6⅝	7⅞	8	¾	⅞	2.416	3120
5	11	1⅜	8 1/16	9¼	8	¾	⅞	2.416	4385
6	12½	1 1/16	9⅛	10⅝	12	¾	⅞	3.624	3915
8	15	1½	11⅛	13	12	⅞	1	5.04	4400
10	17½	1⅞	14 1/16	15¼	16	1	1⅛	8.80	3625
12	20½	2	16 1/16	17¾	16	1⅛	1¼	11.10	3975
14 O.D.	23	2⅛	18⅛	20¼	20	1⅛	1¼	13.88	3735
16 O.D.	25½	2¼	21 1/16	22½	20	1¼	1⅜	17.86	2255
18 O.D.	28	2⅜	23 1/16	24¾	24	1¼	1⅜	21.43	4505
20 O.D.	30½	2½	25 1/16	27	24	1¼	1⅜	21.43	4845
24 O.D.	36	2¾	30 1/16	32	24	1½	1⅝	31.06	4500
30 O.D.	43	3	37 1/16	39¼	28	1¾	2	48.89	5590
36 O.D.	50	3⅜	43⅛	46	32	2	2¼	73.70	5355
42 O.D.	57	3⅛	50 1/16	52¾	36	2	2¼	82.90	5945
48 O.D.	65	4	58 1/16	60¾	40	2	2¼	92.08	7315
SPECIAL SIZES (USE NOT RECOMMENDED)									
4½	10½	1 1/16	....	8½	8	¾	...	.....	....
7	14	1½	....	11⅞	12	⅞	...	.....	....

[1] NOTE—Drilling templates are in multiples of 4, so that fittings may be made to face in any quarter, and bolt holes straddle the center line. For bolts smaller than 1¼ in., the bolt holes shall be drilled ⅛ in. larger in diameter than the nominal size of the bolts. Holes for bolts 1¼ in. and larger shall be drilled ¼ in. larger than nominal diameter of bolts.

[2] NOTE—All 250 lb. cast-iron standard flanges have a 1/16 in. raised face. This raised face is included in the face to face center to face and the minimum thickness of flange dimensions.

[3] NOTE—The stress shown is that of internal pressure only assumed to act on a circular area equal in diameter to the outside diameter of the raised face.

[4] NOTE—For tongue-groove and male-female facings the dimensions given in Table A-5*a* are recommended.

STEEL FLANGED FITTINGS

The following table is taken from publication (B 16*e*—1927) of standards developed by the Sectional Committee on Pipe Flanges and Fittings which has received the approval of the M.S.S.A.F.I., H.P.C.N.A., A.S.M.E. and the American Standards Association

TABLE A-5*b*. DIMENSIONS OF FLANGES FOR MAXIMUM WORKING STEAM PRESSURE AT A TEMPERATURE OF 750 DEG. FAHR.

250 lb.						400 lb.					600 lb.					
Nominal Pipe Size	Outside Diameter of Flange	Thickness of Flange Minimum[1]	Diameter of Bolt Circle	Number of Bolts	Diameter of Bolts	Outside Diameter of Flange	Thickness of Flange Minimum[2]	Diameter of Bolt Circle	Number of Bolts	Diameter of Bolts	Nominal Pipe Size	Outside Diameter of Flange	Thickness of Flange Minimum[2]	Diameter of Bolt Circle	Number of Bolts	Diameter of Bolts
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
¼	3¾	7/16	2⅜	4	½	3¾	7/16	2⅝	4	½	¼	3¾	7/16	2⅜	4	½
¾	4⅝	⅜	3¼	4	⅝	4⅝	⅜	3¼	4	⅝	¾	4⅝	⅜	3¼	4	⅝
1	4⅞	7/16	3½	4	⅝	4⅞	7/16	3½	4	⅝	1	4⅞	7/16	3½	4	⅝
1¼	5¼	7/16	3⅞	4	⅝	5¼	7/16	3⅞	4	⅝	1¼	5¼	7/16	3⅞	4	⅝
1½	6⅛	⅞	4½	4	¾	6⅛	⅞	4½	4	¾	1½	6⅛	⅞	4½	4	¾
2	6½	⅞	5	8	⅝	6½	1	5	8	⅝	2	6½	1	5	8	⅝
2½	7½	1	5⅞	8	¾	7½	1⅛	5⅞	8	¾	2½	7½	1⅛	5⅞	8	¾
3	8¼	1⅛	6⅝	8	¾	8¼	1¼	6⅝	8	¾	3	8¼	1¼	6⅝	8	¾
3½	9	1 7/16	7¼	8	¾	9	1⅜	7¼	8	⅞	3½	9	1⅜	7¼	8	⅞
4	10	1⅜	7⅞	8	¾	10	1⅜	7⅞	8	⅞	4	10¾	1½	8½	8	⅞
5	11	1⅜	9¼	8	¾	11	1½	9¼	8	⅞	5	13	1¾	10½	8	1
6	12½	1 7/16	10⅝	12	¾	12½	1⅝	10⅝	12	⅞	6	14	1⅞	11½	12	1
8	15	1⅝	13	12	⅞	15	1⅞	13	12	1	8	16½	2 7/16	13¾	12	1⅛
10	17½	1⅞	15¼	16	1	17½	2⅛	15¼	16	1⅛	10	20	2½	17	16	1¼
12	20½	2	17¾	16	1⅛	20½	2¼	17¾	16	1¼	12	22	2⅝	19¼	20	1¼
14 O.D.	23	2⅛	20¼	20	1⅛	23	2⅜	20¼	20	1¼	14 O.D.	23¾	2¾	20¾	20	1⅜
16 O.D.	25½	2¼	22½	20	1¼	25½	2½	22½	20	1⅜	16 O.D.	27	3	23¾	20	1½
18 O.D.	28	2⅜	24¾	24	1¼	28	2⅝	24¾	24	1⅜	18 O.D.	29¼	3¼	25¾	20	1⅝
20 O.D.	30½	2½	27	24	1¼	30½	2¾	27	24	1½	20 O.D.	32	3½	28½	24	1⅝
24 O.D.	36	2¾	32	24	1½	36	3	32	24	1¾	24 O.D.	37	4	33	24	1⅞
SPECIAL SIZES (USE NOT RECOMMENDED)																
4½	10½	1 7/16	8½	8	¾	10½	1 7/16	8½	8	⅞	4½	11½	1⅝	9¼	8	1
7	14	1½	11⅞	12	⅞	14	1¾	11⅞	12	1	7	15	2 7/16	12½	12	1⅛

[1] NOTE—A raised face of 7/16 in. is included in minimum thickness of flanges.

[2] NOTE—A raised face of ¼ in. is not included in the minimum thickness of flanges.

TABLE A-5*b*—Continued

900 lb.					1350 lb.				
Outside Diameter of Flange	Thickness of Flange Minimum[2]	Diameter of Bolt Circle	Number of Bolts	Diameter of Bolts	Outside Diameter of Flange	Thickness of Flange Minimum[2]	Diameter of Bolt Circle	Number of Bolts	Diameter of Bolts
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....
5⅞	1⅜	4	4	⅞	5⅞	1⅜	4	4	⅞
6¼	1⅜	4⅜	4	⅞	6¼	1⅜	4⅜	4	⅞
7	1½	4⅞	4	1	7	1½	4⅞	4	1
8½	1⅝	6½	8	⅞	8½	1⅝	6½	8	⅞
9⅝	1⅝	7½	8	1	9⅝	1⅝	7½	8	1
9½	1⅝	7½	8	⅞	10½	1⅞	8	8	1⅛
10¼	1⅝	8½	8	1	11	2	8½	8	1⅛
11½	1¾	9¼	8	1¼	12¼	2⅛	9½	8	1¼
13¾	2	11	8	1¼	14¾	2⅜	11½	8	1⅜
15	2 7/16	12½	12	1⅛	15½	2⅝	12½	12	1⅜
18½	2½	15½	12	1⅜	19	3	15½	12	1⅝
21½	2¾	18½	16	1⅜	23	3½	19	12	1⅝
24	3⅛	21	20	1⅜	25½	4⅛	21½	16	1⅜
25¼	3⅛	22	20	1½	....	....	....	....	....
27¾	3½	24¾	20	1⅝	....	....	....	....	....
31	4	27	20	1⅞	....	....	....	....	....
33¾	4¼	29½	20	2	....	....	....	....	....
41	5⅛	35½	20	2⅛	....	....	....	....	....
SPECIAL SIZES (USE NOT RECOMMENDED)									
13	1⅞	10½	8	1⅜	13½	2¼	10½	8	1⅜
16½	2⅜	13¾	12	1¼	17	2¾	13¾	12	1⅝

[2] NOTE—A raised face of ¼ in. is not included in the minimum thickness of flanges.

vening pipe or fitting. Such intervening pipe or fitting, if used, shall not be longer than the face-to-face dimension [A-A] of the [American Extra Heavy iron flanged tee fitting of corresponding size shown in Table A-6 and Fig. A-9] CORRESPONDING FITTING OF THE SAME DIAMETER AND PRESSURE UNDER THE NEW TENTATIVE AMERICAN STANDARDS. Every safety valve shall be connected so as to stand in an upright position, with spindle vertical, when possible.

PAR. P-286 REVISED:

P-286. A safety valve over 3 in. in size, used for pressures greater than 15 lb. per sq. in. gage, shall have a flanged inlet connection. The dimensions of flanges subjected to boiler pressure [not exceeding 250 lb. per sq. in.] shall conform to the NEW TENTATIVE American [Extra Heavy] Standards given in Tables A-5*a*, AND A-5*b*, OR TABLE A-6*b* [A-6] of the Appendix, except that the face of the safety valve flange and the nozzle to which it is attached may be flat and without the raised face.

PAR. P-299 REVISED:

P-299. *Fittings.* THE flanges [d] OF [cast iron] pipe fittings shall conform to the NEW TENTATIVE American Standards given in the Appendix. If the fittings are below the water line they shall be extra heavy.

[For pressures exceeding 250 lb. per sq. in., the flange thickness, and the thickness of the bodies shall be increased to give at least the same factor of safety as the fittings specified in the Table, when used for the maximum pressures permitted in the Code.]

The face of the flange of a safety valve, as well as that of a safety-valve nozzle, may be flat and without the raised face, for pressures not exceeding 250 lb. but shall have the raised face for higher pressures.

The number of bolts in a flange may be increased, provided they are located on the standard bolt circle. Tables A-5*a*, A-5*b* [A-5] and A-6*a*, A-6*b* [A-6] do not apply to flanges on the boiler side of steam nozzles, or to fittings designed as part of the boiler.

CAST IRON FLANGED FITTINGS

TABLE A-6*a*. DIMENSIONS OF 125 LB. CAST-IRON FLANGES

The following table is taken from publication (B16*a*-1928) of standards developed by the Sectional Committee on Pipe Flanges and Fittings which has received the approval of the M.S.S.A.F.I., H.P.C.N.A., A.S.M.E. and the American Standards Association.

Nominal Pipe Size In.	Outside Diameter of Flange In.	Thickness of Flange Minimum[3] In.	Diameter of Bolt Circle In.	Number of Bolts[2] In.	Diameter of Bolts In.	Diameter of Drilled Bolt Holes[1] In.	Total Effective Area Bolt Metal In.	Stress Lb. per Sq. In. Bolt Metal[3] In.
1	4¼	7/16	3⅛	4	½	⅝	0.504	1340
1¼	4⅝	½	3½	4	½	⅝	0.504	1755
1½	5	7/16	3⅞	4	½	⅝	0.504	2215
2	6	5/8	4¾	4	⅝	¾	0.808	2065
2½	7	11/16	5½	4	⅝	¾	0.808	2885
3	7½	¾	6	4	⅝	¾	0.808	3510
3½	8½	11/16	7	8	⅝	¾	1.616	2410
4	9	11/16	7½	8	⅝	¾	1.616	2870
5	10	11/16	8½	8	¾	⅞	2.416	2440
6	11	1	9½	8	¾	⅞	2.416	3110
8	13½	1⅛	11¾	8	¾	⅞	2.416	4915
10	16	1 3/16	14¼	12	⅞	1	5.04	3485
12	19	1¼	17	12	⅞	1	5.04	5065
14 O.D.	21	1⅜	18¾	12	1	1⅛	6.60	4685
16 O.D.	23½	1 7/16	21¼	16	1	1⅛	8.80	4575
18 O.D.	25	1 5/16	22¾	16	1⅛	1¼	11.10	4145
20 O.D.	27½	1 11/16	25	20	1⅛	1¼	13.88	4030
24 O.D.	32	1⅞	29½	20	1¼	1⅜	17.86	4385
30 O.C.	38¾	2⅛	36	28	1¼	1⅜	25.00	4700
36 O.D.	46	2⅜	42¾	32	1½	1⅝	41.41	4035
42 O.D.	53	2⅝	49½	36	1½	1⅝	46.57	4810
48 O.D.	59½	2¾	56	44	1½	1⅝	56.93	5200
54 O.D.	66¼	3	62¾	44	1¾	2	76.82	4755
60 O.D.	73	3⅛	69¼	52	1¾	2	90.79	4925
72 O.D.	86½	3½	82½	60	1¾	2	104.70	6150
84 O.D.	99¾	3⅞	95½	64	2	2¼	147.33	5825
96 O.D.	113¼	4¼	108½	68	2¼	2½	205.56	5415
SPECIAL SIZES (USE NOT RECOMMENDED)								
4½	9¼	11/16	7¾	8	¾	...	.....	....
7	12½	1 1/16	10¾	8	¾	...	.....	....

[1] NOTE—Drilling templates are in multiples of 4, so that fittings may be made to face in any quarter, and bolt holes straddle the center line. For bolts smaller than 1¼ in. the bolt holes shall be drilled 1/16 in. larger in diameter than the nominal diameter of the bolt. Holes for bolts 1¼ in. and larger shall be drilled ¼ in. larger than nominal diameter of bolts.

[2] NOTE—All 125 lb. cast-iron standard flanges have a plain face.

[3] NOTE—The stress shown is that of internal pressure only, assumed to act on a circular area equal in diameter to the outside diameter of a ring gasket covering the flange to the inside of bolts.

The terminating flanges, however, shall be in accordance with Tables A-5*a*, A-5*b* [A-5] and A-6*a*, A-6*b* [A-6].

PAR. P-302 REVISED:

P-302. The main stop valves of boilers shall be at least extra heavy when the maximum allowable working pressure exceeds 125 lb. per sq. in. The fittings between the boiler and such valve or valves shall be at least extra heavy, as specified in Tables A-5*a*, A-5*b*, AND A-6*b* [A-6] of the Appendix.

ACCORDING to the Bureau of Mines, the United States consumes about one-half of the world's production of tin. During 1927, 24,527 tons of primary or virgin tin were used in the manufacture of tin plate and terne plate, while solder required 13,734 tons. The manufacture of babbitt metal required 8705 tons, and foil and collapsible tubes consumed 6903 tons.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases 609 (Reopened), Nos. 610 (Annulled), and 612–616 as formulated at the meeting on December 13, 1928, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 609 (In the hands of the Committee)

CASE NO. 610 (Annulled)

CASE NO. 612

Inquiry: Is it permissible, under Par. P-268 of the Code, to attach either couplings, one-half couplings or nipples on to boiler plates for blow-off and feedwater connections, by fusion welding, and without tapping the boiler plates and screwing the couplings or nipples in with required number of threads, the strength of such connection being dependent on the strength of the weld?

Reply: Such a nipple or fitting as described may be welded into a boiler plate, if it has a retaining flange or shoulder to rest against the inner surface and sustain the stress due to steam pressure. A hole cut in a drum for such a nipple or fitting cannot be larger than 6 in. in diameter and the fittings cannot be used for larger than 3-in. pipe size except as provided for in Par. P-268. The Power Boiler Code does not permit a fitting or attachment to be welded where the safety of the structure is dependent upon the strength of the weld.

CASE NO. 613

Inquiry: Is it necessary, under Par. P-264 of the Code, to insert manhole openings in all locomotive-type boilers over 40 in. in diameter? Is not the exception for internally fired boilers under 48 in. in diameter applicable to this type of boiler?

Reply: The boiler commonly known as the locomotive type is an internally fired boiler and it is therefore the opinion of the Committee that if the diameter or width of such locomotive-type boiler is not in excess of 48 in. the manhole requirement does not apply.

CASE NO. 614

Inquiry: Do the requirements of Par. P-324 of the Code apply to h.r.t. boilers when they are set in a steel frame which consists of a firebox directly underneath the boiler and the frame

work bolted to the sides thereof? It is pointed out that where the insulating lining has not been properly maintained the plates and supports have buckled and allowed the boiler to lower in the setting.

Reply: The requirements in Par. P-324 contemplate settings which are essentially of brick construction, but it is the opinion of the Committee that in any case where the supports are of structural steel they should be so insulated that their supporting strength cannot be impaired from the heat of the furnace.

CASE NO. 615

Inquiry: Is it necessary, under the requirements of Par. P-301 of the Code, that the stop valve nearest the boiler shall be located directly at or upon the boiler nozzle? Is it not permissible for pipe connections or fittings to be inserted between the nozzle and the first stop valve as reflected in the second sentence of Par. P-302?

Reply: It is not necessary that the first stop valve be located directly at or upon the nozzle of a boiler. Par. P-301 permits of intervening pipe or connections, but indicates a preference for the shortest and most direct connection possible between them.

CASE NO. 616

(In the hands of the Committee)

Magnetic Analysis of Materials

THAT there is a close connection between the magnetic properties of ferrous materials and their other physical properties has long been recognized, and many investigations have been made for the purpose of discovering the nature of the connection. It is only in recent years, however, that investigations along this line have been undertaken with the definite object in view of developing practical magnetic testing methods for routine inspections and for the study of the phenomena associated with the thermal and mechanical treatment of steel. It is the purpose of the present paper to trace briefly the development of magnetic analysis, to indicate its present status, and to suggest lines along which further investigation might profitably be directed.

Space does not permit a detailed discussion of the results of all the investigations recorded in the technical literature. These results, however, are in the main concordant and the following general conclusions may be drawn:

1 Any treatment which alters to a measurable extent the mechanical properties of a piece of steel at the same time appreciably alters its magnetic characteristics, though not necessarily to a corresponding degree.

2 The nature of the effect of various treatments on magnetic properties is generally similar for different types of steel, but this is not a universal rule, as notable exceptions have been observed.

3 Although the magnetic and mechanical properties appear to be functions of the same variables—that is, composition and structure—there are certain secondary effects, notably that of mechanical strain, which exert an influence on the magnetic properties out of all proportion to their effect on the mechanical properties. This is an important point which should never be overlooked in the search for laws of correlation.

Encouraging results have been obtained in the majority of cases, but the obstacle in the way of practical application on a commercial basis is usually the effect of secondary influences. In other words, the test generally fails on the side of safety, but leads to the rejection of an excessive amount of good material. This should not be considered to imply that the outlook is hopeless, but only that the problem is not so simple as it might appear at first glance. The need for a satisfactory non-destructive test is so great that efforts in this direction should not be abandoned until every possibility has been exhausted. And the fact that successful application has been accomplished in even a few cases leads to the conviction that the general problem is not impossible of solution.

A large proportion of the failures of steel parts in service is due not to poor general quality of the materials but to the presence of hidden flaws or defects. It is for the detection and location of hidden flaws that a reliable non-destructive test is most needed. For this reason, a considerable amount of attention has been given to this phase of magnetic analysis, and at least one successful application has been recorded. A large number of different products such as steel rails, rifle-barrel steel, rifle barrels, ball-bearing races, and welded chain have been the subject of study. One of the most important problems is that of the test of welds, for the applicability of welding is seriously limited by the lack of a suitable test for quality of the weld.

During the course of an investigation on high-speed steel carried on by Committee A-8 of the A.S.T.M., several methods were studied by different members of the committee. Although the results of the investigations left much to be desired in the way of definite correlations, the alternating-current methods developed by De Forest seemed to offer the most encouraging field for further study. Two types of inspection have been developed. In the earliest form, the sample under test is compared with a standard by means of an inductance bridge using a separately excited a.c. galvanometer as a detector. By adjusting the phase of the current in the galvanometer field with respect to the induced voltages, it is possible to obtain readings on the galvanometer which depend mainly on the difference in permeability of the two specimens, the difference in hysteresis loss, or various combinations of the two factors. Thus it may be seen that in addition to speed in operation, the method offers great flexibility.

Thermodynamic analysis consists of the study of magnetic changes which occur during heating or cooling of a specimen. While not properly classed as a non-destructive test, thermomagnetic analysis should be considered as one phase of magnetic analysis. Its development and application have received little attention in the United States, but in the hands of the Japanese investigator Honda it has proved to be an exceedingly valuable tool for the study of the phenomena associated with the heat treatment of steel. Apparatus for the application of thermomagnetic analysis has been set up recently at the Bureau of Standards, and it is hoped to develop further this phase of magnetic analysis.

Methods of magnetic analysis have found some application both in the laboratory and in commercial inspection.

In the realm of commercial routine inspection there are three outstanding examples—the inspection of small case-hardened chain, the testing of small heat-treated forgings, and the examination of steam-turbine bucket wheels. The first two are applications of the two types of alternating-current tests developed by De Forest for the American Chain Company. The third-mentioned method is a d.c. exploration test developed by the General Electric Company with the collaboration of Mr. Burrows.

A bibliography of the subject is appended. (Raymond L. Sanford, Chief, Magnetic Section, U. S. Bureau of Standards, Washington, D. C., in a paper before the 1929 Winter Convention of the *American Institute of Electrical Engineers*. Abstracted from preprint no. 29–11, pp. 1–6, 1 fig.)

MECHANICAL ENGINEERING

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K.m-h.

HISTORIC was the gathering in the Engineering Auditorium in New York during the recent A.S.M.E. Annual Meeting to hear the doctrine of "k.m-h." expounded as a new theory of industrial relativity. Alford and Hannum presented their new factor, the kilo man-hour, and by the fortunate availability of data from the Engineering Council's study on Safety and Production, were able to show how this factor can be used as a continuous measure of the fruitfulness of industry. Their paper, the leading article in this issue, shows how the k.m-h. may be used as the denominator of many measuring ratios of productivity, capital investment, costs, profits, and a host of others. Its simplicity of derivation and use attracted the attention of the business and daily press, and provided the news sensation of the meeting.

When engineers develop a new machine or tool they generally lose themselves in admiration of the perfection of their handiwork. Not in this case, however, for steps were immediately taken to put the new device to work. From hearings before the Director of the Census, there seems to be little doubt that data will be provided in the 1929 Census which will permit this new ratio to be profitably used in the fluxing state that industry now finds itself.

Diagnosticians of industrial ills will be grateful to the authors of this paper and to the type of thinking from which it originated, for a simple scheme of bringing the troublesome symptoms of non-profitable industry into view and permitting the remedies to be prescribed.

New Waste Elimination

WITH true vision, the writers of the now famous report on "Waste in Industry" asked that the lessons taught in that valuable book be constantly reiterated, and pointed out that the engineering profession and industrial leaders generally would find opportunity for many years in the future to emphasize the principles it contained and direct the attention of industry to the fruits that may be harvested by constantly eliminating waste.

The A.S.M.E. Management Division and the Local Sections are now engaged in a project with the cooperation of the American Management Association to focus the attention of American industry on means for still further reducing production costs and increasing factory economies. Armed with the experience of several industrial organizations which have savings of thousands of dollars to report, the committees will go forth again to enlist the interest of all industry in support of the movement for greater national economy. Every Local Section of the Society will be given an opportunity to participate in what appears to be a most important Society activity. Waste-elimination projects were once objects of suspicion, but as the soundness of their principles became apparent, a new language was written around them and reflected in the daily press, that what is now wasted might be used to a good advantage to enhance the prosperity of the country. Now industry is seeking more knowledge of these principles and data as to their application. As the originators of these principles and as their promulgators through the old Federated American Engineering Societies, now the American Engineering Council, engineers are fulfilling their destiny in again taking the lead in supporting new efforts for greater industrial economy.

Labor Turnover and the Engineer

FROM information presented at the recent meeting of the American Statistical Association and from other sources which have recently become available, it would appear that substantially only about one-third of the men discharged by a plant go back into the same kind of work that they did before. Of those, only a part obtain the same wages that they did before their discharge. To an engineer, these figures are highly significant. To understand them correctly, it is necessary to remember that entirely unskilled labor is already a comparatively small factor in American production. Hence the above figures apply to skilled or semi-skilled labor, and if two out of three men discharged from a plant go into other lines of occupation, the skill which they have previously acquired is lost. However, it costs money to teach a man to do even the simplest task, and the greater the experience of a man, the more of an investment does he represent. It is true that part of this investment is his own and is represented by his willingness to accept lower wages during his early period of employment. Another part of the same investment, however, is made by the plant employing him in the way of direct training, slower production until the necessary skill is acquired, and probably a higher percentage of spoiled goods during the same period.

The engineer who is responsible for production at a cost has, however, to consider also another angle, and that is, that whenever a man is discharged, sooner or later another man will have to be put in his place. Judging from the above figures, out of three such new men probably only one will have had previous experience in exactly the same line of work, while the other two will probably be coming from other lines of employment and will have to be trained anew.

It would therefore appear that the policy of hiring men in boom times and beginning to fire them as soon as the least indications of slack appear, may be statistically right, but from the point of view of its influence on production, and particularly on costs, it is entirely wrong. The engineer has to have good tools if he is to do good work, and the term "tools" broadly applies to the machinery of production as well as to the man power which is

back of that machinery and essentially forming an integral part thereof.

During the panic of 1907, one of the large electrical manufacturing companies dismissed practically its entire research staff in the belief that hard times were coming, when business would be slow and there would be no money for research anyway. Its largest competitor did not follow this policy. The country recovered from the panic much faster than any one expected, and when reasonably good times came back, the company without the research staff was unable to handle properly new problems such as constantly arise in the electrical-engineering field. The business therefore went to its competitor, and gave the latter an advantage which persisted for the next twenty years.

This is of course a rather extreme example of the danger of achieving economies by incidentally increasing the labor turnover, but even when this turnover is only slightly greater than it should be, the major part of the expense falls on the man whose business it is to get goods at a cost that will please the sales department, and if this doesn't happen to be the case, then it is the engineer who is blamed for the high cost of the goods.

Research in Alloys of Iron

THE American Institute of Mining and Metallurgical Engineers, with the support of Engineering Foundation, has instituted a project of fundamental research in alloys of iron. The research was outlined by a committee consisting of John Johnston, Chairman, Director of Research and Technology, United States Steel Corporation; F. M. Becket, President, Union Carbide and Carbon Research Laboratories; H. W. Gillett, Chief, Division of Metallurgy, Bureau of Standards; James T. MacKenzie, Metallurgist and Chief Chemist, American Cast-Iron Pipe Company; and A. J. Wadhams, Manager of Research and Development, International Nickel Company.

The research, as planned, will have two divisions:

1 Critical review of all available literature in English and other languages, resulting in series of monographs and manuals; for this division a fund of $150,000 is needed —a small cost for the benefits to so numerous and great industries;

2 Research directed toward increasing fundamental knowledge of iron and its combinations with other substances, particularly alloys of *pure* iron with one or two or three or more other *pure* metals, also the effects of the impurities incident to practical operations. For this division other provision will be made.

First Division. Each monograph will contain in the most compact, convenient form all that is worth while in the voluminous literature on a specific subject. It will be compiled by competent men, under able supervision, with the advice and review of the best authorities. These monographs will be indispensable to research and development men in the industries, and to investigators working in university, governmental, and private laboratories.

Into the manuals in convenient form for the technical staffs of furnaces, mills, foundries and shops, and for consulting, designing and inspecting engineers, will be put the facts useful to them, critically selected from the literature by specialists and subject to review by men chosen with regard for the intended uses of the manuals.

These monographs and manuals will be printed and sold at prices that will cover cost of publication and possibly yield a surplus that will help to provide for continuation of the work. Fundamental and industrial research and practical experience will continually add to knowledge. Hence it will be necessary to revise the monographs and manuals from time to time, according to progress in the several subjects.

A critical review of the literature will also reveal the gaps, inaccuracies, and disagreements in present records. It will indicate which data are unreliable and where research is most needed. Its principal benefit will be making the dependable statements of knowledge readily usable.

Second Division. Much research has been and is being carried on in industrial laboratories to discover and develop alloy irons and alloy steels for a great variety of purposes. Relatively much less fundamental research has been done on iron itself and the metals that combine with iron. More, and in some instances more accurate, fundamental data would make possible the conduct of industrial researches with greater intelligence and assurance, and would result in substantial economies of cost and time.

Two or three corporations whose laboratories are doing fundamental research on alloying metals have already agreed to contribute their results as part of the cooperative Alloys of Iron Research. Two universities have undertaken specific portions of the work. There are good prospects for similar arrangements for other items.

Review of the literature is to have precedence and is to be prosecuted as rapidly as practicable; for it a fund of $150,000 for five years' work is now sought.

Laboratory work in Division 2 will be undertaken in such manner as to expedite and not impede work on the literature. It is expected that some of this work will be contributed by industrial and other laboratories. Funds offered by the Engineering Foundation are available for a beginning, but will have to be supplemented later.

The New Einstein Theory

THE most remarkable thing about this theory for the present appears to be the amazing amount of interest manifested in it by the general public. In effect, Dr. Einstein has published a six-page mathematical investigation of the relation between gravitational and electromagnetic phenomena. He himself very plainly states that this investigation has not led as yet to any practical results. At best it clears up certain conceptions in the highest realm of mathematical physics, of which the general public until quite recently barely realized the existence; and yet the first announcement of the theory was front-page matter in practically all metropolitan dailies. When the theory was first made public, the leading journals at once either secured brief explanations from eminent mathematicians which the average man was entirely incapable of understanding, or went to the trouble of translating the test and reproducing the involved mathematics used.

Ten or twenty years ago such an interest in a purely mathematical investigation on the part of the general public would have been unthinkable. Apparently, although quantum mathematics is still beyond the mental level of the average man, the general public has nevertheless acquired a sufficient amount of scientific culture to make it take at least as great an interest in an important advance in science as it does in a heavyweight championship or a sensational murder.

To the scientist or engineer this is extremely promising. The more interest the general public takes in subjects of this kind, the more will workers in the field of research and engineering become available as time goes on, and the greater will be the willingness of the public to provide means for carrying on both research problems and engineering construction. Obviously, in a democracy like that of the United States, popular support, interest, and encouragement are vitally necessary to make any art or science progress to full fruition.

Economies of the Steel Industry in 1928

THE situation in the steel industry in 1928 was a very remarkable one, reflecting more than ever the tendencies which have become apparent in this great industry within the last decade.

The volume of business which the steel companies did was enormous. Even if it did not quite reach the record-breaking level of 1926, it nevertheless approached it quite closely, and what is more, in 1928 the demand was uniformly great throughout most of the year. On the other hand, such is the excess of producing capacity available that even in as great a year as 1928 the level of prices remained substantially the same throughout that period, and only to a very small extent reflected the nearly record-breaking demand for steel products. Practically all steel companies made excellent profits during the year, and it becomes of interest to learn how and why these profits were made.

Analysis would indicate that one of the reasons why the year was so profitable lay in the fact that the demand was large and steady, and yet not too great. While the figure is more or less conjectural, it would appear that steel mills can work at their utmost efficiency when their production is within about 85 per cent of capacity. When production falls below that, the overhead and fixed charges per unit of output become too great, and in this way reduce profits. When production is in excess of 85 per cent capacity, it means rush work—with all that that implies—and decrease of tonnage per dollar of expenditure for labor, with the result that while production increases, the cost per unit of output likewise increases. In 1928 the mills were working to about 85 per cent of capacity, which means essentially at or around their average maximum efficiency.

Another element of great importance which affected the industry in 1928 was that many of the improvements which were started around 1923–1924, i.e., when it became clear that unrestricted immigration was a matter of the past, began to bear fruit in 1928. Thus, for example, in that year the Bethlehem Steel Co. completed its extensive program of reconstruction of the mills of the original company, as well as of those of the Lackawanna and Midvale companies which it took over some years ago.

It has been stated by an officer of the Bethlehem company that the sum of $4 per ton was saved by this program of mill modernization which, including the new mills which were installed, cost about $160,000,000. An officer of one of the other large companies stated to the writer of this editorial that according to his estimates from $4 to $5 more could be cut off the cost of production of steel by introducing methods already known, i.e., not involving any radical inventions or modifications of present processes. He stated, however, that the cost of the installation of new machinery and reconstruction of the old necessary to achieve such a saving in mill costs would be such as to increase the fixed charges to an extent that would make the whole undertaking of doubtful advantage.

It would therefore appear that while great to some extent, the prosperity of the steel industry has been illusory in that it has been attained by improvements which not only reduce costs but will rapidly tend to increase the capacity of the mills.

At the same time it must be remembered that there is another tendency which is acting counter to the one above stated, namely, what might be called coagmentation, but which is more generally referred to as mergers. Some of these mergers have been effected, such as that between the Republic and Trumbull companies in the field of plain steels, and between the Ludlum and Atlas on one hand, and that involving the Vanadium Alloy Steel Co. on the other. Certain larger mergers are openly under consideration, as for example, that between the Youngstown Sheet & Tube Company and the Inland Steel Company, while the very extensive stock holdings of the so-called Cleveland group (generally represented by Otis & Co., Pickands Mather & Co., etc.) in a number of large steel producers would indicate that even should a recession in demand occur, there would not be too unreasonable price cutting. On the whole, therefore, the immediate future of the American steel industry, assuming proper protection from dumping of foreign goods, appears to be unusually bright.

I.E.C. Conference on Resistivity of Aluminum

A CONFERENCE on Resistivity of Aluminum was held at the Laboratoire Central d'Electricité, Paris, on November 16, 1928, to consider proposals for the values of the electrical and other qualities of aluminum for transmission lines with a view to recommending them to the International Electrotechnical Commission for adoption as standard. Prof. Paul Janet, Director of the Laboratoire Central d'Electricité, presided, and the following delegates were present:

France	
M. R. JOUAUST	Laboratoire Central d'Electricité
M. DE BIRAN	Aluminium Francias
M. LAMBERG	Tréfileries de Rai-Tillières
M. MARQUAUX	Tréfileries du Havre
Germany	
HERR DR. APT	Deutsche Gesellschaft für Metallkunde
HERR PROF. DR. VON STEINWEHR	Physikalisch - Technische Reichsanstalt
HERR OBERINGENIEUR WUNDER	Representative of users
Great Britain	
DR. E. H. RAYNER	National Physical Laboratory
MR. E. T. PAINTON	British Aluminium Co.
United States of America	
DR. G. K. BURGESS	Director, Bureau of Standards
MR. W. C. BINZ	Representative of the Aluminum Co. of America
MR. B. E. BASSETT	Representative of the Aluminum Co. of America
DR. C. O. MAILLOUX	Representing U. S. National Committee of I.E.C.

The subject has been under consideration for some years, information having been interchanged on a large number of experimental determinations made at the chief national laboratories of the resistivity, density, and other qualities of both hard-drawn and annealed material. It was considered that sufficient information of this nature had been obtained, and that the subject had reached a stage when commercial interests were more particularly involved.

The type of aluminum considered was restricted to hard-drawn material in the form of wire, the annealed being left for consideration at a later date if it be thought desirable eventually to formulate standards for the softer material. The effect of annealing is considerable, usually resulting in a lowering of resistance of more than 1 per cent. It was decided that it was of first importance to prescribe an upper limit of resistivity with which all commercial supplies of aluminum should comply. The chief reason for considering this as being important is the fact that the presence of impurities, if they exceed about 0.5 per cent, are liable to increase appreciably the tendency to corrosion. Since increase in impurity is accomplished by an increase of resistivity, a limit to the resistivity permissible acts sufficiently approximately as a limit to the risk of corrosion. It is also necessary to define "hard-drawn" since resistivity increases with increased strength such as would be obtained by cold working, and in consequence resistivity standards must refer to a well-defined

range of tensile strength. These matters and other physical characteristics necessary for specification purposes were agreed to on the following lines:

The resistivity of commercial hard-drawn aluminum wire at 20 deg. cent. is not to exceed 2.873 microhms per cubic centimeter. This is to apply to wire before being stranded into a cable. If the wire is tested after having been stranded, an increase of 1 per cent of the above value is permitted. The wire is required to withstand for 1 minute a stress of 16 kilograms per square millimeter (22,760 pounds per square inch). The density of aluminum is assumed to be 2.703 at 20 deg. cent. The temperature coefficient of lineal expansion is 23×10^{-6}. The temperature coefficient of resistance is 0.004.

It was considered desirable to adopt a definite nominal value for the resistance of commercial aluminum, which could be used in designing transmission lines. It would naturally be less than the the maximum mentioned above. It was thought that this should be the average value of good material as at present manufactured. In order to obtain information on which such a value might be founded, it was decided to postpone a decision on the subject until after March, 1929, and that in the meantime the countries interested should send the necessary information to the Central Office of the International Electrotechnical Commission.

U.E.S. Report for 1928

OUTSTANDING among the achievements of 1928 was the memorial at Louvain, Belgium, to the engineers of the United States who gave their lives in the Great War of 1914–1918. A new and equitable basis for contributions of the Founder Societies to the support of Engineering Societies Library was adopted with their unanimous approval. A public-address equipment was installed in the Engineering Auditorium at a cost of approximately $7000. Special committees gave attention to the Founder's Agreement, the increase of endowment for the Engineering Foundation and the Engineering Societies Library, and memorials in the Engineering Societies Building and regulations governing them. New committees were appointed near the close of the year to study future development and needs of the societies in the building, and the depreciation and renewal fund. The Finance and House Committees faithfully performed their usual duties, and the former gave thought to improvement in the management of the depreciation and renewal and trust funds. No change was made in banks, financial adviser, legal counsel, or auditors. The Engineering Societies Building and its equipment are in excellent condition.

The eighth floor and storage space in the Engineering Societies Building vacated by the National Electric Light Association at the end of 1927 were soon occupied by other organizations after a few changes in partitions. At the close of 1928 all space was in use. To the best of our information, the building is again wholly free from taxation.

The Society of Naval Architects and Marine Engineers presented a portrait medallion of its former president, the late Admiral Stevenson Taylor. This memorial was accepted and placed on the wall of the sixth-floor hallway pending final placement under the regulations.

The Endowment Committee continued developments of its plans and organization and the solicitation of contributions to the funds of the Engineering Societies Library and the Engineering Foundation. If the additional resources immediately needed are to be obtained within a reasonable time, more members of the societies in all parts of the country should help the Committee. Especially is it desirable that efforts be made by members able to influence persons of means, or corporations. If the appropriations of the societies toward the maintenance and development of their national library are to be supplemented as they should be, and if the funds for aiding their research committees are to be increased, more members must take active persistent and effective interest. In March, Herbert Hoover was appointed a member of the Endowment Committee, and of its Executive Sub-Committee. In October, H. Hobart Porter resigned and in December T. R. Beal, President, Central Hudson Gas and Electric Company, was appointed to fill the vacancy.

In January, the Central Hudson Gas and Electric Company contributed $10,000 to the Engineering Foundation fund. In April, a legacy of $921 ($1000 less inheritance tax) from the late Oberlin Smith was allocated to the Library.

The Committee on War Memorial to American Engineers carried through successfully its project to place a memorial carillon and clock in the tower of the new library at Louvain, Belgium, in honor of the engineers of the United States who gave their lives in the Great War of 1914–1918. The Committee's expenditures will total approximately $89,000, of which $65,000 was contributed by engineers in all the states and territories of our country, and the remainder was paid from a guarantee fund generously provided by the chairman. Sixteen national societies participated in obtaining the contributions. The Library and the Engineers' Memorial were dedicated on July 4 with impressive ceremonies attended by many engineers from America. This memorial is an important token of international goodwill. It is highly prized by the University of Louvain. The government's appreciation was expressed through the conferring by King Albert upon the Committee's chairman of the distinction of Commander of the Order of the Crown of Belgium. A full report is being prepared by the Committee for submission to the Trustees as soon as certain minor business items shall have been closed.

Memberships of the Founder Societies at the end of 1928 totaled 59,300, and of Associate Societies, 22,100, an aggregate of 81,400 engineers having headquarters in our building.

The treasurer's report for the year is given below.

SUMMARY

OPERATION OF BUILDING

Credit balance January 1, 1928		$7,331.35
Insurance refund and adjustment		2,253.90
Building revenue, 1928	$130,551.72	
Building expenditures, 1928	111,767.59	18,784.13
		$28,369.38
Annual payment to Depreciation and Renewal Fund		12,000.00
Credit Balance December 31, 1928		$16,369.38

OPERATION OF LIBRARY

Maintenance revenue	$46,009.65	
Maintenance expenditures	45,584.10	
Credit balance, December 31, 1928		$425.55
Service Bureau revenue	$20,261.47	
Service Bureau expenditures and adjustments	19,163.80	
Credit balance, December 31, 1928	$1,097.67	
Credit balance, January 1, 1928	2,830.19	
Total credit balance December 31, 1928		$3,927.86

FUNDS AND PROPERTY

Funds held by U.E.S. Dec. 31, 1928 (book value):	
Depreciation and Renewal	$233,743.73
General Reserve	5,773.40
Engineering Foundation	517,753.95
Henry R. Towne Engineering	49,953.13

Library Endowment	104,652.22
Reserve for Depreciation of Capital of Library	4,000.00
Edward Dean Adams	100,000.00
John Fritz Medal (U.E.S. Custodian)	3,500.00
Louvain Memorial Fund (cash in bank)	9,470.51
Total	$1,028,846.94
Real Estate owned by U.E.S., cost to Dec. 31, 1928.	1,973,410.42
Operating cash and petty cash	14,251.47
Accounts receivable	2,032.96
Value of Library (as appraised for insurance)	348,056.00
Winchell Library Suspense Account	374.35
Unexpired fire-insurance premiums	6,340.55
Total property for which U.E.S. is trustee or custodian	$3,373,312.69

BALANCE SHEET

ASSETS

Real Estate		
Land	$ 540,000.00	
Building	1,376,239.26	
Equipment	33,171.16	
Founders' preliminary expenses	24,000.00	$1,973,410.42
Investments and Cash Uninvested		
Depreciation and Renewal Fund		$233,743.73
General Reserve Fund		5,773.40
Engineering Foundation Fund		517,753.95
Henry R. Towne Engineering Fund		49,953.13
Library Endowment Fund		104,652.22
Reserve for Depreciation of Library Capital		4,000.00
Edward Dean Adams Fund		100,000.00
Louvain Memorial Fund—cash in bank		9,470.51
Operating cash and petty cash		14,251.47
Accounts receivable		2,032.96
Winchell Library Suspense Account		374.35
Unexpired fire-insurance premiums		6,340.55
		$3,021,756.69

LIABILITIES

Founders' equity in property	$1,973,410.42
Depreciation and Renewal Fund	233,743.73
General Reserve Fund	5,773.40
Engineering Foundation Fund	517,753.95
Henry R. Towne Engineering Fund	49,953.13
Library Endowment Fund	104,652.22
Reserve for Depreciation of Library Capital	4,000.00
Edward Dean Adams Fund	100,000.00
Louvain Memorial Fund Balance	9,470.51
Endowment Committee Reserve (balance on hand)	702.57
Endowment Contribution (undesignated)	1,000.00
Louvain Memorial Dinner (cash on hand)	225.00
Deposits on account of hall rentals	328.00
Deposits—Library Service Bureau	20.97
Credit balance in activity accounts	20,722.79
Total	$3,021,756.69

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The Laws of Management Applied to Manufacturing

LAWS OF MANAGEMENT APPLIED TO MANUFACTURING. By L. P. Alford. Ronald Press Co., New York, 1928. Cloth, 6 × 9 in., 266 pp., $4.

REVIEWED BY H. L. SEWARD[1]

THOSE members of the A.S.M.E. who were present at its Annual Meeting in December, 1926, and heard Mr. Alford's presentation of his paper entitled "Laws of Manufacturing Management," will recall that the ensuing discussion emphasized the importance of this step in the development of the science of management and characterized the paper as an outstanding contribution to the literature of management science. Few papers presented in the last decade have been given a more cordial and commendatory reception. Mr. Alford's contribution made every one realize that the cause of intelligent management in manufacturing had made a distinct advance and that the science had now become of age, because, as R. T. Kent said, it had gone through the three general stages of development necessary for the rounding out of a science: namely, the collection of a mass of somewhat unrelated facts and data; the correlation of these data and the derivation from them of some general principles; the application of these principles to concrete cases; and finally, the formation of laws based on the results of application of the principles. The modern management movement, although barely a quarter of a century old with the presentation of this paper, passed through all of these phases.

The author did not feel that the paper was necessarily complete, but offered it "in the hope that further investigation would be stimulated which would help to more firmly establish the laws of management as securely as the laws of mathematics . . . . are fixed today." He was not disappointed in this hope, because in the discussion there were offered many suggested laws and some different points of view in the codification of some of the laws.

Under the new title "Laws of Management Applied to Manufacturing," Mr. Alford has brought out a book which is in itself an excellent example of the use of the scientific method of the coordination of effort in the way he has utilized the suggestions made in the discussion and in correspondence resulting from the presentation of the original paper. Those who studied that paper will welcome the more acceptable style of presentation, the regrouping of ideas, the use of more definitive verbs, and the added

[1] Associate Professor of Mechanical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn. Mem. A.S.M.E.

illustrations and authorities included in the book. Many diversified examples have been introduced to illustrate the meaning of the laws, a better discussion of division of labor, specialization, and standardization has been given, and the whole work offers much less resistance to those who would find that quality too much for them in the original paper. It offers a broader and more comprehensive presentation than the original paper, and is to be recommended as a teachable and valuable text for those who seek to comprehend the fundamental ideas of management now available for manufacturing.

Some footnote references might have an added value if the date, or at least the year, were included, and one wonders why graphical methods of presentation were not used to further illustrate Chapter VII; but a mature teacher or reader can perhaps gain more by adding these from his own searches or experience.

As a member of some of the important committees of the Society concerned in the progress of management for many years, the author has had unusual opportunities of spanning the pioneer period and the application period. His training and experience, and the regard in which he is held by his associates, all tend to give this book the stamp of authoritativeness.

Factory Organization and Management

THE PRINCIPLES OF FACTORY ORGANIZATION AND MANAGEMENT. By Ralph Currier Davis,[1] New York. Harper & Bros., 1928. Cloth, 6 × 9 in., 449 pp., 133 figs., and 29 plates, $5.

REVIEWED BY JOHN YOUNGER[2]

MANY books are being published these days on factory management and organization, and this the latest follows largely in the paths of the others.

In the preface Professor Davis states:

> In writing this book the author has had in mind the difficulties which confront the student of industrial management or the junior executive who aspires to greater responsibilities, when he attempts to obtain a broader and more complete understanding of the fundamentals and the work of factory management. Accordingly an effort has been made to draw a clear picture of the fundamental functions and principles of factory organization and management and their relations to one another.
>
> While it is intended primarily for the elementary student of the subject, it is hoped that the book will find favor in the eyes of experienced executives in so far as it records some of the more advanced management practices and the more important trends in modern management.

In the volume itself many forms are illustrated, but practically no charts. Perhaps this omission is accounted for by the author's refusal to discuss distribution problems, and yet these problems have an important effect on the production and personnel curves. This lack of contact will be noticed by many readers.

Positive rules are laid down for the provision of good illumination, but little is said as to its effects on production, inspection, and safety. Heating and ventilating are treated in a brief paragraph.

Similarly the engineering department is discussed in a brief four pages, with little indication as to the important part it plays in providing the designs and bills of material—the foundation of a production and planning system.

Little if any effort seems to be made to distinguish between job shops and production shops in their control; and no mention is made of the modern use of conveyors as a means of controlling the speed of materials, nor is there much if any treatment of the economics of management.

Having drawn attention to some of the omissions, let us congratulate the author on his lengthy and thorough treatment of production and planning, material and its control, and personnel, these three large subjects occupying over half of the book.

Finally let us quote two interesting paragraphs. On quality control Professor Davis states:

> It is most desirable that the degree of quality produced be maintained invariably, in so far as economical manufacturing permits, in order that the public in purchasing units of the particular kind or brand may have confidence that it will always receive this degree. The scrap problem is brought under control. By varying the strictness of inspection, the percentage of loss can be controlled for economical production, within the limits set by the standards of quality. By pointing out the causes of scrap, the inspection organization can be a powerful influence for its reduction. With such reduction there are fewer interferences to production due to the scrapping, replacing, or reworking of materials. Consequently the ease and accuracy with which production is controlled are increased.
>
> The maintenance of the highest standards of quality consistent with economical manufacturing and the class of goods being produced, does not necessarily mean a reduction in the per capita production of the plant. In fact, many industrial executives feel that if quality is properly controlled, quantity will follow as a natural consequence.

And on time study he states:

> Neither the college graduate nor the practical shop man is entirely satisfactory as raw material for a time-study man. The first has highly developed analytical powers and greater possibilities for development. Usually he has a good scientific foundation and, in the case of engineering graduates, a good technical training. The practical shop man may be bound by shop traditions regarding the best methods of doing work and reasonable standards of production. The college graduate has not had these ideas ingrained into him. On the other hand, he often lacks experience and suffers from an unjustifiable feeling of superiority.
>
> The practical shop man probably will lack the good qualities of the college man, but he has the advantage that he has had extensive practical experience with the work that is being studied, and he may be able to work with the men better for the reason that he has their point of view.
>
> The ideal candidate is the college graduate who has the qualities which have been mentioned previously and who has had considerable practical shop experience.

The book is a good addition to the rapidly growing library of management, and will be read with interest.

Books Received in the Library

A.E.F. VERHANDLUNGEN DES AUSSCHUSSES FÜR EINHEITEN UND FORMELGRÖSSEN IN DEN JAHREN 1907 BIS 1927. Edited by J. Wallot. Julius Springer, Berlin, 1928. Paper, 9 × 12 in., 49 pp., 5 r.m.

This pamphlet is a new edition (revised) of the decisions of the Committee for units and symbols representing the principal German physical and electrical societies, containing the mathematical symbols and units of measurement approved by the committee and the decisions regarding their use. To students of German works and to all interested in the standardization of symbols and terminology, the book will be of much interest.

THE AIRPLANE AND ITS ENGINE. By Charles Hugh Chatfield and Charles Fayette Taylor. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 8 in., 329 pp., illus., diagrams, tables, $2.50.

This book attempts to fill a middle ground between the wants of those interested in romantic aviation and those in search of highly technical information. It appeals to those who wish a sound knowledge of basic facts and theories but do not wish to give to the subject the intensive study required of the designer or builder. We have here a sound, yet simple, discussion of the principles, construction, and capabilities of airplanes and airplane engines.

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[1] In Charge Industrial Management Courses, General Motors Institute of Technology, Flint, Mich. Assoc-Mem. A.S.M.E.

[2] Professor of Industrial Engineering, Ohio State University, Columbus, Ohio. Mem. A.S.M.E.

ARTIFICIAL SILK. By Valentin Hottenroth. Isaac Pitman & Sons, London and New York, 1928. Cloth, 6 × 9 in., 421 pp., illus., tables, $8.50.

A translation of the principal German work on this substance. It gives a very comprehensive account of the industry, from its beginnings, and is especially valuable because of its scope, all known processes being described, and its attention to practical details. Includes a useful bibliography.

AUTOMOTIVE GRINDING. By Fred B. Jacobs. Penton Publishing Co., Cleveland, Ohio, 1928. Cloth, 6 × 9 in., 146 pp., illus., $2.

Illustrates and describes the numerous types of grinding operations now used in automobile factories, such as cylindrical grinding, internal grinding, surface grinding, disk grinding, cam grinding, centerless grinding, and piston grinding. Advice is given on the selection of wheels and on testing, on the design of grinding machines, and the handling of work. Although the book is confined to grinding in automobile factories, the methods shown can be applied to precision grinding in all lines of work.

DIE BELASTBARKEIT DER WÄLZLAGER. By Helmut Stellrecht. Julius Springer, Berlin, 1928. Paper, 7 × 10 in., 98 pp., illus., 9 r.m.

The author's aim is to provide a more scientific basis for designing ball bearings and roller bearings. He analyzes the stresses to which these bearings are subjected and derives formulas by which the load that a given bearing can carry may be calculated accurately. These formulas enable the designer and manufacturer to select suitable dimensions for a bearing and to avoid the use of unduly large safety factors.

DIE BERLINER MASCHINEN-INDUSTRIE UND IHRE PRODUKTIONSBEDINGUNGEN SEIT IHRER ENTSTEHUNG. By K. Doogs. Julius Springer, Berlin, 1928. Paper, 6 × 9 in., 121 pp. maps, tables, 10 r.m.

A historical and economic study of the manufacture of machinery in the Berlin district. The development of the industry is traced historically from the beginning of the eighteenth century and also from various economic and technical points of view. The reasons and effects of this development are traced and future prospects discussed.

CENTRALES ÉLECTRIQUES. By F. Drouin. J.-B. Baillière et fils, Paris, 1928. Paper, 6 × 9 in., 602 pp., illus., diagrams, 85 francs.

A comprehensive survey of electric power-plant practice, as exemplified by good modern examples. The book is descriptive in nature and covers all important topics.

LES CHEMINS DE FER URBAINS PARISIENS. By Louis Biette. J.-B. Baillière et fils, Paris, 1928. Paper, 6 × 9 in., 523 pp., illus., diagrams, 90 francs.

A very complete description of the rapid-transit system of Paris. Full details are given on the engineering features of the subways and elevated lines, on the methods used in constructing these, on the financial arrangements, and on their history.

LES CYCLES IRREVERSIBLES ET LA TURBINE VAN DEN BOSSCHE. By J. Van den Bossche. *Chaleur & Industrie*, Paris, 1928. Paper, 6 × 9 in., 38 pp., diagrams.

The Bossche turbine, in place of the customary reversible Rankine cycle, uses an irreversible cycle which is not governed by the second law of thermodynamics and hence does not require a drop in temperature. The pamphlet explains the principle of the irreversible cycle, discusses the theoretical advantages of the new turbine, and describes its construction and operation in detail.

DER EINFLUSS DES COS ϕ AUF DIE TARIFGESTALTUNG DER ELEKTRIZITÄTSWERKE. By Hans Nissel. Julius Springer, Berlin, 1928. Paper, 6 × 9 in., 54 pp., illus., diagrams, tables, 4.50 r.m.

This monograph is a study of the principles underlying tariffs for electric power. In the first part the author describes the functions showing the relation of load factor to the capital cost and losses of an electric works, and from them derives a theoretically correct load-factor tariff.

As this theoretical tariff is not unstable in practice, the author then studies the tariffs actually used and ascertains which is the most desirable substitute for the theoretical one. He selects the apparent-power tariff as the most desirable.

DER EISENWASSERBAU, vol. 1; Theorie und Konstruktion der beweglichen Wehre. By H. Kulka. Wilhelm Ernst & Sohn, Berlin, 1928. Paper, 7 × 10 in., 323 pp., illus., diagrams, 29 r.m.

This is the first volume of a work planned in two volumes, which will treat the special topic of steel structures in hydraulic engineering. The volume, which may be used independently, is devoted to movable weirs.

The author first explains the mathematical principles of hydrodynamics and endeavors to provide the necessary theoretical principles for the design of structures subjected to hydraulic forces. He then treats the various kinds of weirs, paying special attention to fundamentals and applying the information presented in the first part of the book to these different types. The hydraulic and mechanical peculiarities of each are discussed, as well as economic considerations.

ELECTRIC DRIVE PRACTICE. By Gordon Fox. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 8 in., 421 pp., illus., diagrams, tables, $3.50.

Successful application of electric motors to machine driving requires, among other things, knowledge of the requirements of the machinery to be driven and consideration of every aspect of its motion that affects the drive. The present book is intended to give this information for those classes of machinery which are in common use in many industries. It discusses motor drives for blowers, compressors, pumps, cranes and hoists, elevators, mine hoists, machine tools, and industrial traction. The elements of load are evaluated and the factors that affect the determination of the size of motor for each kind of machine are pointed out. The functions of the different machines, the laws governing their action, and their distinctive requirements are enumerated, assisting the reader to select the proper motor for any given purpose.

ESSENTIALS OF COST ACCOUNTING. By L. Cleve'and Amidon and Theodore Lang. Ronald Press Co., New York, 1928. Cloth, 6 × 9 in., 383 pp., forms, $4.50.

This text is intended to give the student a clear understanding of the technique of cost accounting. To accomplish this, the subject is developed from his previous knowledge of general accounting, a minimum amount of detail is included, and only brief consideration is given to the managerial uses of costs. Attention is directed primarily to grounding the student in accounting procedure.

FROM MAGIC TO SCIENCE; ESSAYS ON THE SCIENTIFIC TWILIGHT. By Charles Singer. Boni & Liveright, New York, 1928. Cloth, 6 × 10 in., 253 pp., illus., plates, $7.50.

This handsomely printed volume contains seven essays by Dr. Singer, which have appeared in various previous publications, but which are now presented in revised form as contributions to the history of science. The author's object is to trace the slow decline of the observational sciences from the intellectual

efficiency of classical antiquity and the earliest steps in the recovery.

The first essay gives a picture of science under the Roman Empire. Succeeding chapters trace the rapid deterioration of ancient science into magic, and the beginnings of the redevelopment of scientific thought and method. Dr. Singer's study ends with the twelfth century.

FUNCTIONS OF REAL VARIABLES. By E. J. Townsend. Henry Holt & Co., New York, 1928. Cloth, 6 × 10 in., $5.

This textbook is based upon the course given at the University of Illinois, and is a companion book to the author's work on complex variables. It presupposes a training in the usual undergraduate course in mathematics, and discusses those topics that will give the student a better grasp and understanding of the fundamental principles of the calculus of real variables, and some knowledge of recent developments of the subject.

GRAPHISCHE STATIK, vol. 2, second edition. By Otto Henkel. Walter de Gruyter & Co., Berlin and Leipzig, 1928. Cloth, 4 × 6 in., 176 pp., diagrams, 1.50 r.m.

A textbook for the student who wishes to acquire a knowledge of the more important applications of graphic statics without extended theoretical study, and a concise reference book for engineers in practice.

HANDBOOK OF DOMESTIC OIL HEATING. Edited by Harry F. Tapp. American Oil Burner Association, New York, 1928. Fabrikoid, 5 × 8 in., 383 pp., illus., diagrams, tables, $3.

A practical treatise on the heating of residences by oil-fired furnaces. The subjects include the calculation of the heating equipment necessary, the properties of fuel oil, comparative heating costs, oil-burning equipment, heating systems, installation, testing etc.

HANDBUCH FÜR FLUGZEUGFUHRER. By H. G. Bader. V.D.I. Verlag, Berlin, 1928. Cloth, 6 × 8 in., 193 pp., illus., 12 r.m.

In the eight papers here published, eight experts discuss the influence of design upon the flying qualities of airplanes, power plants, instruments, test flying, the organization of air traffic, the commercial flier, meteorology, and airplane building. The work is intended as a handbook for builders and organizers of air services.

HARVARD BUSINESS REPORTS, vol. 6. Compiled by Graduate School of Business Administration, Harvard University. A. W. Shaw Company, Chicago and New York, 1928. Cloth, 6 × 9 in., 554 pp., $7.50.

The cases in this volume of business reports are all concerned with industrial marketing. They report the actual experience of various concerns with problems of sales organization, advertising, sales promotion, pricing, distributing channels, and related matters. Commentaries on each case are given by the editors.

DIE HEBEZEUGE, bd. 2; FÖRDERMITTEL IM BETRIEB. By G. Tafel. Walter de Gruyter & Co., Berlin and Leipzig, 1928. Cloth, 4 × 6 in., 143 pp., illus., 1.50 r.m.

A useful little summary of information on hoisting and conveying machinery. Attention is called to all existing types, the advantages and disadvantages of each are pointed out, and practical assistance in selecting appropriate machinery for a given purpose is supplied.

HISTORY OF MATHEMATICAL NOTATIONS, vol. 1: Notations in Elementary Mathematics. By F. Cajori. Open Court Publishing Co., Chicago, 1928. Cloth, 6 × 9 in., 451 pp., illus., $6.

Professor Cajori gives an elaborate account of the way in which the symbols of elementary mathematics originated, of their spread among different writers and of the competition that they encountered. The volume opens with a description of the numerical symbols used by various nations of antiquity, and of the introduction and adoption of the present system. Following this, the symbols used in elementary arithmetic, algebra, and geometry are discussed. The book is illustrated by numerous interesting facsimiles of early texts and contains extensive bibliographic notes. It will not only be useful to students of the history of mathematics and of present-day problems of notation. but also of general interest to all users of mathematics.

HÜTTE; Taschenbuch für Betriebsingenieure. Third edition. By Akademische Verein Hütte, E. V. in Berlin. Wilhelm Ernst & Sohn, Berlin, 1929. Cloth, 5 × 8 in., 1215 pp., illus., diagrams, tables, 35 r.m.

This recent addition to the library of concise handbooks is intended for the factory superintendent and works manager. The subjects discussed include the principles of interchangeable manufacturing, machine drives, balancing of machinery, factory buildings, works organization, labor laws, foundry practice, welding and brazing, forging and stamping, hardening and heat treating, metal cutting, and spray painting. This edition contains new sections on a number of important topics.

INDUSTRIAL CARBON. By C. L. Mantell. D. Van Nostrand Co., New York, 1928. (Industrial Chemical Monographs.) Cloth, 6 × 9 in., 410 pp., illus., tables, $4.50.

In addition to its use as fuel, carbon has many uses in industry. Diamonds as used for drilling, as graphite for crucibles and other refractory products and as a lubricant. Carbon is also used as a pigment, a decolorizer, and for a variety of electrical purposes.

The various technical uses of carbon, aside from its use for fuel, are described in the present book. The information on the preparation, properties, and uses of carbon products contained in the work has only been available heretofore after search through widely scattered sources. Its collection obviates much labor and provides a convenient work of reference in a neglected field.

INDUSTRIAL EXPLORERS. By Maurice Holland and Henry F. Pringle. Harper & Bros., New York, 1928. Cloth, 6 × 9 in., 347 pp., portraits, $3.

Nineteen biographical sketches of living Americans of note in industrial-research work. Through the lives of these leaders, the authors emphasize the importance of science to industry and call attention to the contributions of industrial research to the comfort of modern life. A readable, interesting book.

INTRODUCTION TO THE THEORY OF EDDY-CURRENT HEATING. By C. R. Burch and N. Ryland Davis. Ernest Benn, London, 1928. Cloth, 6 × 9 in., 72 pp., illus., diagrams, 12 s. 6 d.

The authors of this little book, two Cambridge physicists engaged in industrial research, have developed the mathematical theory of the induction furnace and applied it to furnace design and construction. Their efforts have resulted in formulas by which the capital cost, running cost, and properties of a furnace of given dimensions may be predicted, and furnaces based on their predictions have operated most successfully.

LUFTFAHRTFORSCHUNG, bd. 2, heft 5. December 15, 1928. R. Oldenbourg, Munich and Berlin, 1928. Paper, 8 × 12 in., pp. 111–160, illus., diagrams, 9.40 r.m.

The first paper in this publication is an extensive mathematical investigation of the influence of working conditions, such as power, velocity of revolution, speed of flight, and air density, on the efficiency of air screws. The second gives the results of tests on the strength of bolts in wooden structures, particularly airplane frames.

MACHINES HYDRAULIQUES. By Louis Bergeron. Dunod, Paris, 1928. Paper, 5 × 8 in., 881 pp., illus., diagrams, 108.75 francs.

This volume, based upon the practical experience of the author and upon numerous special investigations of hydraulic problems, is a concise encyclopedia of hydraulic machinery. The essential theory is developed entirely with elementary mathematics and the descriptive portion covers an unusual variety of pumps, rams, turbines, hydraulic presses, etc.

MATERIALS HANDBOOK. By George S. Brady. McGraw-Hill Book Co., New York, 1929. Fabrikoid, 4 × 7 in., 428 pp., $4.

A convenient little reference book on abrasives, metals and alloys, building materials, fibers, textiles, paints, chemicals, oils, minerals, and woods used in industry. The materials, arranged alphabetically, are briefly described, with some indications of their properties and uses. A valuable feature is the inclusion of many new proprietary alloys.

MECHANICAL POWER TRANSMISSION. By William Staniar. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 9 in., 409 pp., illus., tables, $5.

A practical exposition of all phases of the subject, covering not only belting but also all the accessories, such as bearings, shafting, pulleys, chains, speed controllers and reducers, belt shifters, etc. Discusses also the maintenance and lubrication of transmission machinery. The author describes current methods in detail and explains how and where to use them. Theory is omitted, the treatment being based on operating results and experiences. The book is based on the author's experience in the plants of E. I. du Pont de Nemours & Co. and the General Motors Co.

MÉTHODES GRAPHIQUES POUR L'ETUDE DES INSTALLATIONS DE CHAUFFAGE ET DE RÉFRIGÉRATION EN RÉGIME DISCONTINU. By André Nessi and Léon Nisolle. Dunod, Paris, 1929. (Physique Industrielle.) Paper, 8 × 11 in., 168 pp., graphs, diagrams, 96.25 francs.

A thorough mathematical discussion of the design of heating plants, in which the calorific capacity of building materials and variations in external temperature are taken into account. This complicated problem the authors solve analytically, and finally express their results in a series of graphic charts which can be applied directly to the determination of the proper sizes of heating plants and to their economical operation under varying temperatures. The method is applicable, the authors state, not only to the heating of buildings, but also to all problems of industrial heating and of refrigeration.

MOLECULAR REARRANGEMENTS. By C. W. Porter. Chemical Catalog Co., New York, 1928. (American Chemical Society. Monograph series.) Cloth, 6 × 9 in., 167 pp., $4.

This monograph presents our knowledge of unimolecular reactions which modify the structure of the molecule, and provides references to the original researches. The author reviews and classifies the important types of rearrangements and presents the principal theories relating to mechanisms.

PHOSPHORESZENZ UND FLUORESZENZ, vol. 2. By P. Lenard, Fred. Schmidt and R. Tomaschek; also, Lichtelektrische Wirkung, by P. Lenard and A. Becker. Akademische Verlagsgesellschaft, Leipzig, 1928. (Handbuch der Experimentalphysik, v. 23, pt. 2.) Cloth, 7 × 10 in., pp. 745–1544, illus., tables, 72 r.m.

This volume contains the conclusion of the treatise on phosphorescence and fluorescence, together with the section on photoelectricity. The treatment is encyclopedic and thorough, bringing together our knowledge on these subjects in convenient form for reference, and providing references to original sources. Will be useful to all engaged in research.

LA PHYSIQUE DE LA GRAVITATION ET LA DYNAMIQUE DE L'UNIVERS. By Thomas Tommasina. Gauthier-Villars et cie, Paris, 1928. Paper, 7 × 10 in., 301 pp., portrait, 50 francs.

A critical study of the fundamental notions of physics and astronomy. The author views with disfavor many modern theories, particularly those of Einstein, and offers instead a purely mechanical and material explanation of the nature of all physical and astronomical phenomena.

PRINCIPLES OF SCIENTIFIC PURCHASING. By Norman F. Harriman. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 9 in., 301 pp., graphs, forms, $3.

Treats concisely of fundamental, economic, technical, financial, legal, psychological, and allied aspects of purchasing. Inspection and the budgetary control of purchasing are also treated, as well as the purchasing organizations and procedures of several large companies. A bibliography is included. Hitherto books on purchasing have been chiefly concerned with standard forms and routine office methods. Such discussions of general principles as the present are rare.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the Aeronautic, Machine-Shop Practice, Petroleum and Printing Industries sections of A.S.M.E. Transactions as published in its new form. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

AERONAUTIC PAPERS

THE PROBLEM OF SOLID FUEL INJECTION IN HIGH-SPEED FLEXIBLE OIL ENGINES. By A. C. Attendu. [Paper No. AER-50-18]

The "flexible" oil engine, the author states, is one which must be capable of starting from cold on its own fuel without preheating of that fuel or the aid of a combustion chamber or electric appliances, or by the preliminary use of a lighter oil for warming-up purposes. It must be able to start cold at 70 to 100 r.p.m., idle to 125 r.p.m. or about, and run from that speed up to a maximum which varies from 1000 r.p.m. for trucks, light marine engines, and the like, to 1800 to 2000 r.p.m. as required for aviation. The author describes his recent work in the development of a system of solid fuel injection that will meet the demands of the flexible engine, and gives particulars of a new type of fuel pump and an injector provided with a mixing chamber in the cylinder head which he believes will lead to the desired result.

THE STATUS OF THE AIRSHIP IN AMERICA. By Gilbert Betancourt. [Paper No. AER-50-19]

After discussing various handicaps to rigid-airship development in America, prominent among which is the higher cost of manufacturing such craft in this country, the author proceeds to deal briefly with various academic problems, and controversial matters which have engaged the attention of the small group of American airship engi-

neers. In so doing he takes up the questions of airplanes vs. airships, fabric or metal airships, large or small ships, commercial or military airships, and the use of helium or hydrogen. He also discusses types of airships, fineness ratio and form, tail surfaces, location of engines and cars, and of keels or cabins. All these, the author asserts, present no barriers to the establishment of what he believes will be the shipbuilding industry of the century.

A COMPARATIVE EXAMINATION OF THE AIRPLANE AND THE AIRSHIP. By Carl B. Fritsche. [Paper No. AER-50-20]

Dealing particularly with their commercial application to transatlantic service, the author institutes an extended comparative examination of the two types of aircraft, from which he concludes: (1) That the airplane, large or small, has a comparatively short range, is physically unsuited to overseas service, and that its use in transatlantic flying is unsafe and should be discouraged; (2) That with suitable intermediate stops provided for refueling, the large flying boat has possibilities for overseas service, but cannot compete successfully with the rigid airship in economy, comfort, and safety; and (3) That the large rigid airship will always be supreme in long-distance heavy-cargo transport. In the author's opinion it is the duty of the Government to provide liberal appropriations for its improvement and advancement to the point of development where private capital is justified in undertaking the responsibility alone.

THE THEORY OF LONG-DISTANCE FLIGHT. By Robert J. Nebesar. [Paper No. AER-50-21]

This paper treats of speed at minimum drag, the reciprocal relations of the aerodynamic values, the influence of the decreasing weight of fuel during the flight, the variation of long-distance-flight conditions with altitude, and the influence of the decreasing load of fuel on the altitude of flight.

SLOTTED WINGS. By F. Handley Page. [Paper No. AER-50-22]

In the original Wright airplane, as in all its successors of fixed wing area, the only means used for varying the lift was by alteration of the angle of incidence or of the camber of the wing, either by warping or by the equivalent use of ailerons. Such a variation in lift was and is used either for the purpose of varying the speed of the airplane or, applied to one portion of the wing surface only, for controlling the aircraft. The author has developed the slotted wing described in the paper, which is a device for safeguarding airplanes against stalling, nose dives, and tail spins, and its use is serving to extend use of those original angular limits within which aircraft may be safely flown and the original Wright control used, and further so to improve the control as to make safe that range of stalled flight in which the original type of control was and is of no avail.

HEAVY-OIL ENGINES FOR AIRCRAFT. By D. R. Pye. [Paper No. AER-50-23]

In this paper the author first points out that the heavy-oil engine will probably provide a satisfactory practical power unit for airships long before it reaches the airplane stage. He then briefly describes early experimental work with a single-cylinder research unit to explore the possibilities of compression-ignition operation. Following this he discusses alternative designs which offer possible solutions of the main problem, and then gives results obtained in single-cylinder experiments showing the effect of maximum cylinder pressure upon brake m.e.p. and fuel consumption. Fuel-valve and nozzle design are then taken up, followed by sections dealing briefly with air swirl, valve mechanism, possibilities of the two-stroke cycle, and performance at altitude.

PREPARATION OF AN AIRLINE FOR COMMERCIAL OPERATIONS. By J. G. Ray. [Paper No. AER-50-24]

In this paper the author deals briefly with the selection of line, equipment, and personnel, the operating divisions of the line, the equipment of division points, test flying of the line, and the training of pilots.

TECHNICAL DEVELOPMENT OF THE REED METAL PROPELLER. By S. Albert Reed. [Paper No. AER-50-25]

The Reed propeller is an aircraft propeller with solid, thin, and almost knifelike blades of forged or rolled duralumin or other aluminum alloys of similar type which have about the same lightness as aluminum and the strength of mild steel. The author gives particulars regarding its development, the several types which have been made, the materials entering into its construction and the methods of manufacture. Stress calculations are given for a type R propeller made in 1927 for U. S. Government service.

MODERN AIRPORTS AND AIRPORT PLANNING. By B. Russell Shaw. [Paper No. AER-50-26]

This paper deals briefly with early landing gear and methods of launching planes; development of present methods; airport development; landing surfaces; drainage; possible future launching methods; terminal facilities; and illumination. In conclusion the author points out that flying fields are not airports unless they are provided with the facilities described in the paper.

SOME ECONOMIC FEATURES AFFECTING COMMERCIAL AVIATION. By Carl E. Trube. [Paper No. AER-50-27]

This paper is a discussion of the value of speed in saving transportation time, the ideal and most desired range of airplanes, the earning abilities of different airplanes operating at different airport-to-airport scheduled speeds, and the influence of power, size, and scheduled speed of airplanes on the profit-making possibilities of a passenger-transport enterprise.

APPLICATIONS OF BALSA WOOD IN AIRCRAFT. By G. L. Weeks, Jr. [Paper No. AER-50-28]

According to the author, the extreme lightness of balsa wood (7.3 lb. per cu. ft.) makes it an ideal material for airplane construction, and it is now used in such parts as outboard struts, fillets, fuselages, wing ribs and tips, strut fairings, etc. The paper includes a table of strength properties of the wood, and its value in sound proofing and as an insulator against heat or cold is briefly discussed.

MACHINE-SHOP PRACTICE PAPERS

INSPECTION METHODS AND QUALITY CONTROL IN THE MANUFACTURE OF AIRCRAFT-ENGINE PARTS. By Hugh W. Roughley. [Paper No. MSP-50-15]

Within the last decade manufacturers carrying on quantity production have come to recognize the importance of efficient inspection throughout all process of fabrication and assembly, and in the manufacture of aircraft engines it has been found of paramount importance. In this paper the author, who is quality manager of a prominent aircraft-engine manufacturing concern, discusses in some detail its practice in the inspection of raw material, forgings, small parts, and castings, as well as inspection during manufacture and final inspection upon the completion of each engine part.

HIGH-SPEED GEARING. By Ira Short. [Paper No. MSP-50-16]

Reduction gears, employed to transmit power from steam turbines to apparatus which must operate at much slower speeds, must, to be successful, be efficient, silent in operation, reliable, and long-lived. These requirements are met in correctly designed and carefully manufactured helical-tooth gearing. The author, in discussing the reduction gears made by the Westinghouse Electric & Manufacturing Co. deals with the action of gears, the wear of gear teeth, wear due to pitting, allowable loading of teeth, importance of correct alignment, lubrication of teeth, and noise in gears and its elimination. Typical reduction gears are also described and illustrated.

THE PRATT & WHITNEY GEAR-SHAVING PROCESS. By H. D. Tanner. [Paper No. MSP-50-17]

This gear-shaving process is a practical method of generating involute spur on helical gears at 0 deg. The cutting tools are actuated by a cam carrying two opposed involutes, and the gears cut are spur or helical according as their straight cutting edges are parallel to or at an angle with the center line of the gear. It is preferable to rough-cut the gears and then use this process as a finishing one. Details of the machines, cams, cutting blades, and setting of the latter are given in the paper.

SOME PRACTICES IN THE USE OF MACHINE TOOLS IN THE ELECTRICAL INDUSTRY. By J. R. Weaver. [Paper No. MSP-50-18]

The author discusses practices necessary to meet special requirements, such as the use of standard machines with special holding fixtures, operation of several machines by a single operator, etc. He also compares various operations and the methods of forming them, notably planing vs. milling, grinding, welding of fabricated parts, die casting, hot pressing of brass or copper castings and forgings, etc.

PETROLEUM PAPERS

THE DEGREE-DAY METHOD OF FUEL-CONSUMPTION ANALYSIS. By W. R. Abbott. [Paper No. PET-50-4]

The "degree-day," is the product of 1 deg. fahr. and one 24-hour day. Within the limits of the author's company's requirements, the fuel consumption for a given heating plant has been found to be in direct proportion to the elapsed degree-days. The company therefore employs it in planning its delivery of fuel oil to customers whom it has provided with automatic oil-burning equipment for domestic use. Details of procedure are given in the paper.

DISTILLATION AND FRACTIONATION IN THE PETROLEUM INDUSTRY. By H. R. Swanson. [Paper No. PET-50-5]

In the author's opinion, with the efforts of refinery engineers in the direction of simplification of the distillation operation and equipment, the single-tower unit would seem to be the solution of a previously complex problem. Contingent matters which must be carefully considered are: (1) the selection of a simple, accessible, and practicable heat-recovery system, and (2) the simplest possible sealed piping arrangement.

THE CONSTRUCTION AND PROTECTION OF OIL AND NATURAL-GAS PIPE LINES. By W. H. T. Thornhill. [Paper No. PET-50-6]

After calling attention to the magnitude of the underground systems required for the transportation of oil and natural gas, the author considers in detail the methods employed in field construction, dealing successively with surveying the route, purchasing and preparing the right of way, "stringing" the pipe along the route, welding pipe joints, excavating the ditches, lowering of line into the ditch, laying all-coupled lines, etc. He then takes up the subject of river crossings, following which he discusses at length methods of protecting pipe lines from soil corrosion, and the principal requirements which a good protective coating should meet. Such a coating, the author states, provides reasonable insurance against the destruction of large investments in permanent underground pipe lines.

ONE EXAMPLE OF CENTRIFUGAL PUMPS FOR PETROLEUM TRANSPORTATION. By F. E. Warterfield, Jr. [Paper No. PET-50-7]

This paper deals with the problems involved in one specific installation of motor-driven centrifugal pumps for pipe-line work. The author describes conditions prior to the installation, and gives the reasons for the selection of centrifugal pumping units, as well as actual construction and operating costs so far as possible. He also discusses the effect that the experience gained from the installation described may have on the future use of centrifugal pumps in petroleum transportation.

PRINTING INDUSTRIES PAPERS

PUMPING PROBLEMS IN PAPER MILLS. By Helmer N. Anderson. [Paper No. PI-50-1]

This paper describes a centrifugal trash pump of recent design which is said not to clog when handling high-density paper stock nor pull the water away from the pulp. Its efficiency is said to be good and its power consumption low, and while handling large capacities, the floor space required is small and the investment is not excessive.

PULP-GRINDER CONTROL REDUCES PAPER COSTS. By Adolph F. Meyer. [Paper No. PI-50-2]

Large amounts of power are used in grinding wood pulp for use in paper, and unregulated pulp-grinder loads vary greatly and rapidly. This paper describes a governor for controlling water-wheel-driven and motor-driven pulp grinders and points out the economies effected through such regulation. Governors operating on the waterwheel gate are impracticable and undesirable for the purpose of controlling the speed of waterwheels driving pulp grinders. The Meyer governor maintains uniform friction load, and thereby uniform speed, by varying the pressure with which the wood is pushed against the grindstones. As a speed regulator for water-wheel-driven grinders it is actuated by turbine speed. As a load regulator for motor-driven grinders it is actuated by the load on the grinder motors, which it maintains constant. This paper also describes a master regulator by means of which the total kilowatt load on a given system is maintained constant. The master regulator functions through the load regulators on the individual grinder motors. It automatically distributes the increases or decreases in total grinder load necessitated by decreases or increases in load elsewhere in the system, equally or in any other desired proportion, among the several motors by automatically changing the load setting of the individual regulators. The rate of action of the master regulator to correct load changes is proportional to the variation of the total load from normal at the given moment. No electrical contacts or relays are used, yet great sensitiveness is secured.

ENGINEERING IN THE PRINTING INDUSTRIES. By Edward T. Miller. [Paper No. PI-50-3]

The author, who is secretary of the United Typothetae of America, briefly discusses some of that organization's efforts toward introducing engineering principles into the printing industry, and outlines what may yet be accomplished not only by it but by other associations and societies representing other groups in the graphic arts.

NOTE: Those who have not registered in the A.S.M.E. Aeronautic, Machine-Shop Practice, Petroleum and Printing Industries Divisions, whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

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AIR COMPRESSORS

Developments. Refinements Characterize Compressed Air Trends, F. A. Halleck. Power Plant Eng., vol. 32, no. 24, Dec. 15, 1928, pp. 1344–1345, 1 fig. Improvements in governing systems, use of aftercoolers, water traps and air filters are problems being given greater consideration; speeds will be higher in future; compressor speed; type of drive; unloading system.

AIRCRAFT ENGINES

Cylinders. Improved Cast Iron Cylinder for Air-Cooled Engines, R. A. Brewer. Inco, vol. 8, no. 3, 1928, pp. 15 and 21, 1 fig. Analyzing cost of major units, cylinder stands out predominant as possible source of cost reduction; problem was to obtain uniformity of structure, eliminate weak spots and also to apply support to cylinder so that stresses were not concentrated and complicated; most satisfactory metal, final contents of iron.

Diesel. Advantages of Diesel-Type Aircraft Engine Pictured from Tests, L. M. Woolson. Automotive Industries, vol. 59, no. 25, Dec. 22, 1928, pp. 892–897, 6 figs. Details of high-speed compression-ignition solid-fuel injection Packard Diesel engine developed for airplanes; ignition and carburetor troubles practically eliminated; fire danger reduced; fuel cost lower; less noise from exhaust; engine will operate satisfactorily from any position and is not affected by rain or water; elimination of radio interference; possible effect of engine on airplane design. Abstract of paper presented before Soc. Automotive Engrs.

Testing. Aircraft Engine Testing, G. H. Walker. Aeroplane (Lond.), vol. 35, no. 26, Dec. 26, 1928, pp. 1007–1008 and 1010, 7 figs. See also Flight (Lond.), vol. 20, no. 52, Dec. 27, 1928 (Aircraft Engineer), pp. 100–104, 8 figs. Requirements of British Air Ministry in testing of airplane engines; details of Froude hydraulic dynamometer and of Heenan-Fell air-brake dynamometers; description of wind tunnels purchased by Bristol Aeroplane Co. from Heenan and Froude for use in testing airplane engines; testing Bristol Jupiter engine; Heenan and Froude equipment furnished Argentine Naval Aviation Station.

Dynamometer Testing of Airplane Engines, C. E. Platzer and R. F. Johnston. Aviation Eng., vol. 1, no. 3, Dec. 1928, pp. 10–11, 3 figs. Principles of operations of electric dynamometer and its advantages as means for testing airplane engines are discussed; test of water-cooled engines; altitude chambers used in tests; load and fuel consumption curves for Wright Whirlwind J-5C and J-5CA taken on dynamometer; problem of providing air for air-cooled engines while testing on dynamometer.

AIRCRAFT MANUFACTURE

Gluing. About Glue and Gluing Practice, C. L. Ofenstein. Aviation, vol. 24, no. 27, Dec. 29, 1928, pp. 2099, 2112, 2114, 2116 and 2118, 3 figs. Glue and gluing practice among commercial aircraft factories; casein especially described; testing for adhesiveness and water resistance after glue has been mixed according to directions, some sort of mechanical mixer having two speeds is recommended; glue receptacles should be cleaned out once a day; high pressures for thick glues.

AIRPLANE PROPELLERS

Characteristics in Flight. Characteristics of Five Propellers in Flight, J. W. Crowley, Jr., and R. E. Mixson. Nat. Advisory Committee for Aeronautics—Report No. 292, 1928, 23 pp., 22 figs. Investigation to determine characteristics in flight of four propellers differing uniformly in thickness and pitch, and of fifth which was identical with one of others except for change in airfoil section; efficiencies in flight were consistently lower than in model tests; conclusion that for accurate comparisons it is necessary to know propeller pitch angles under actual operating conditions.

Design. Design of Aircraft Propellers (Calcolo delle eliche), A. Zezi. Notiziario Tecnico di Aeronautica (Rome), vol. 7, no. 11, Nov. 1928, pp. 1–80, 36 figs. Review of theoretical researches; presentation of author's original method of analysis and design; author's method compared with study by Durand and Leslie.

Influence of Fuselage on Propeller Design, T. Troller. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 492, Dec. 1928, 11 pp., 5 figs. on supp. page. Simple method for designing propeller for given arrangement of airplane parts; inflow to propeller and efficiency of propeller affected most by fuselage; flow conditions in plane of propeller, which are affected by shape of fuselage; determined mathematically; condition for best thrust distribution; induced efficiency of propeller calculated. From Zeit. fuer Flugtecnik und Motorluftschiffahrt, July 28, 1928, previously indexed.

Propeller Problems, A. Betz. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 491, Dec. 1928, 13 pp., 3 figs. on supp. plate. Comprehensive survey of most important propeller problems; detached propeller considered; propeller slipstream and propeller blade theories; conditions on best thrust distribution; special care must be exercised to avoid excessive angle of attack in starting which would cause air flow to separate from blades and thus interfere with their normal functioning; reactions between propeller and vehicle are discussed.

Metal, Failure of. Preliminary Study of Fatigue Failures of Metal Propellers Caused by Engine Impulses and Vibrations. Air Corps Information Cir., vol. 7, no. 618, Aug. 15, 1928, 17 pp., 7 figs. Study of cause and prevention of breakage of certain metal propellers in bending in plane perpendicular to propeller axis; causes investigated with particular reference to phenomena of resonance; theory presented in detail; cantilever beam, dynamic load, on propeller blade due to constant acceleration of hub; mathematical analysis of vibration of propeller in plane of rotation; frequencies of similar propellers.

AIRPLANES

Ailerons, Forces Produced by. Determination of Air Forces and Moments Produced by Ailerons of Airplane (Bestimmung der durch die Querruder eines Tragfluegels erzeugten Luftkraefte und Momente), C. Wieselsberger and T. Asano. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 19, no. 13, July 14, 1928, pp. 289–293, 10 figs. Lift distribution produced by aileron deflections for rectangular wing on straight flight previously determined on theoretical principles for certain case, and air forces and moments produced by ailerons derived; approximate values deduced from former results for use in calculating acting forces and moments for all cases; results expressed by non-dimensional coefficients represented in diagrams.

Anti-Friction Bearings in. Anti-Friction Bearings in Aircraft Construction, W. B. Moore. Aviation Eng., vol. 1, no. 3, Dec. 1928, pp. 7–9, 5 figs. Application of anti-friction bearings to airplanes from engineering and practical view is discussed; suitability of bearings of any type for service; advantages; application of tapered roller bearings to main crankshaft and rocker arms of airplane engine to carry both radial and thrust loads; load characteristics and service requirements encountered in application of anti-friction bearings to landing and tail-wheels.

Biplane, Freight. Boeing Building Mail Plane Fleet. Aviation, vol. 25, no. 27, Dec. 29, p. 2106. Few details of new biplane Model 95

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

for handling mail and express only; 525-hp. Hornet engine; four mail and express compartments have cargo capacity of 1600 lb.; wing span 44 ft. 3 in.; body of steel and dural construction, durat and fabric covered; wood wings.

Commercial, Design of. Commercial-Airplane Design (Der Verkehrsflugzeugbau), A. Gymnich. Luftfahrt, (Berlin), vol. 32, no. 23, Dec. 7, 1928, pp. 364–368, 7 figs. Problems of design are discussed from standpoint of pilot; monoplane is favored in Germany, Holland, and United States, whereas England favors biplane and in France both types are employed to about equal extent; one cannot be called superior to other; aileron construction; steering gear.

Metal, Manufacture of. New Construction in Metal Airplanes, F. H. Colvin. Am. Mach., vol. 69, no. 26, Dec. 27, 1928, pp. 983–986, 7 figs. Advanced method of constructing airplane fuselage and way in which aluminum alloy sections are built up, drilled, and riveted for Navy planes in plant of Glenn L. Martin Co. are described; alignment of fuselage claimed difficult with construction of welded tubing; Eureka built-up section developed by engineers of Martin Co. is described; fuselages of high-strength aluminum alloy with chrome molyldenum steel fittings.

Structures of Thin Sheet Metal, Their Design and Construction, H. Wagner. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 490, Dec. 1928, 21 pp., 32 figs. on supp. plates. Uses of sheet-metal coverings in conjunction with inner structure; special methods of construction on which author worked with Rohrbach firm, and which enables simple and cheap shop work combined with great simplicity and lightness; Junkers, Brequet, and Dornier construction; flat sheet-metal girders with very thin webs; buckling strength of flat metal sheets; curved sheet-metal girders.

AIRSHIPS

Metal, Construction of. Metal Airship Construction. Engineer (Lond.), vol. 146, nos. 3803 and 3804, Nov. 30 and Dec. 7, 1928, pp. 598–599 and 622–625, 18 figs. Nov. 30: Description of Boulton and Paul's most recent practice with particular reference to work which it has carried out for Government airship R 101; materials entering into airship structure. Dec. 7: In addition to rolling and drawing of various sections in steel and in duralumin, contract involves manufacture of large number of joints, sockets, shackles, and other details.

ALLOYS

[See also ALUMINUM ALLOYS; BEARING METALS; BRONZE; IRON ALLOYS; MAGNESIUM ALLOYS.]

ALUMINUM

Welding. Aluminum Welding, F. Grove-Palmer. Metal Industry (Lond.), vol. 33, no. 22 and 23, Nov. 30 and Dec. 7, 1928, pp. 509–510 and 533–534 and 546, 3 figs. There is different technique for welding sheet and castings, for castings are more brittle, and with increased thickness there is greater liability of cracking due to expansion and contraction during working; annealing zones are weakest parts of job; care is required for duralumin; far better results obtained from cylinder gas, though more expensive than generator gas; flux should consist of chemical salts that will melt earlier than duralumin and will dissolve oxide.

ALUMINUM ALLOYS

Machining. Machining of Aluminium Alloys, M. Kurrein. Metallurgist (Supp. to Engineer, Lond.), Nov. 30, 1928, pp. 164–165. In light of modern knowledge of cutting process, it is not surprising that cutting tools of all kinds provided with edges and driven at speeds suitable for steel do not give satisfactory results with aluminum alloys; two main factors emerge; angles of tool faces forming cutting edge and speed with which tool is driven; particulars of various types of milling cutter which can be advantageously used for light alloys. Translated from German.

AMMONIA CONDENSERS

Heat Transfer in. Heat Transfer in Ammonia Condensers, A. P. Kratz, H. J. MacIntire and R. E. Gould. Univ. Ill. Eng. Experiment Station—Bul., vol. 26, no. 14, Dec. 4, 1928, 28 pp., 18 figs. Bulletin comprises study of effect of certain changes in condensing surface of vertical shell-and-tube condenser and extension of investigation to include study of heat transfer in double-pipe superheat remover used in connection with previous tests on shell-and-tube condenser.

ASH HANDLING

Mechanical. Mechanical Removal of Ashes in Steam Boilers (L'évacuation mécanique des cendres dans les chaudières a vapeur), M. Sohm. Chaleur et Industrie (Paris), vol. 9, no. 102, Oct. 1928, pp. 133–145 including discussion, 17 figs. Description of mechanical, pneumatic and hydraulic processes of handling ash; report of test made at mines of Bruay.

AUTOMOBILE ENGINES

Detonation. Two Theories Advanced to Account for Engine Detonation, O. A. Ross. Automotive Industries, vol. 59, no. 26, Dec. 29, 1928, p. 950. Phenomenon may be due to electrostatic ignition or to reaction of gas molecules following secondary explosion; tests with cone-shaped bombs suggested.

Junkers. Junkers Automobile Engine (Der Junkers-Fahrzeugmotor), W. Bernhard. Waerme (Berlin), vol. 51, no. 48, Dec. 1, 1928, pp. 886–887, 3 figs. Details of special development of Junkers stationary double-piston oil engine; combustion and scavenging process and their results.

Rotary Valve. A Supercharging and Scavenging Engine. Autocar (Lond.), vol. 61, no. 1730, Dec. 28, 1928, p. 1421, 2 figs. Details of rotary-valve power unit designed by W. R. Ridings, that promises high power at low revolutions; engine consists of double-diameter cylinder and piston mounted above crankshaft; four ports in cylinder head, two being for inlet and exhaust, respectively, and other two being openings to transfer passages cast in cylinder walls and communicating with larger bore of cylinder; supercharging effect is outlined.

AUTOMOBILES

Carburetors. See CARBURETORS.

Clutches. The Borg and Bech Clutch. Automobile Engr. (Lond.), vol. 18, no. 249, Dec. 1928, p. 472, 3 figs. New model of single-plate type, embodying rubber and fabric cushioning device, is described; driven disk is thin sheet of steel ingeniously perforated to provide necessary axial yield in engagement; ease with which clutch may be adjusted.

Front Wheel Drive. Front Wheel Drive—A Coming Development, W. F. Bradley. Autocar (Lond.), vol. 61, no. 1727, Dec. 7, 1928, pp. 1281–1284, 9 figs. What has actually been done with this form of power transmission and what is likely to be done in future are discussed; body builders probably strongest partisans of front-wheel drive; advantages in racing and touring cars; suspension ought to be better with front-wheel drive; difficulties in use; details of Tracta, Alvis, Chaigneau-Brasier, and Bucciali front-wheel-drive cars.

Gears and Gearing, Hardening of. Continuous Furnace Improves Gear Hardening Process. Automotive Industries, vol. 59, no. 25, Dec. 22, 1928, pp. 904–908, 4 figs. Practice of Warner Gear Co. is discussed; upsetting for all gears insisted upon; forging temperature; ideal way of annealing forgings en masse is to have them pass through series of heating and cooling zones maintained uniform by automatic pushing and fuel control; Hump furnace method best but lot of electrical, metallurgical, and mechanical attention necessary; cyaniding methods; eliminating high quench; best quenching temperatures. Abstract of paper presented before Am. Soc. Steel Treating.

Tractive Resistance. Tractive Resistance of Automobiles and Coefficients of Friction of Pneumatic Tires, T. R. Agg. Iowa State College of Agric. and Mechanic Arts Official Pub.—Eng. Experiment Station, vol. 26, no. 70, May 2, 1928, 60 pp., 50 figs. Report deals principally with investigations of certain actions and reactions between road surfaces and tires used on self-propelled vehicles; measurements of air resistance on automobiles by method of mounting automobile on dynamometer carried by flat car and to push car ahead of electric locomotive; coefficient of friction between automobile tires and road surfaces.

Transmission Gears. Gears of the Spontan Corporation (Getriebe der Spontan Aktiebolaget), J. Liebel. Motorwagen (Berlin), vol. 31, no. 32, Nov. 20, 1928, pp. 783–789, 22 figs. In design worked out by F. Ljungstrom of Sweden all operations except steering are performed over single pedal; as in case of Constantinesco and De Lavaud design, mechanical torque converters are employed but great advantage of Ljungstrom design is that these are brought into action only when starting, climbing, and speed changing; planetary gear is supplanted by system of eccentrics; detailed description is given and explanation of mechanical principle upon which it is based.

AUTOMOTIVE FUELS

Acetylene. Acetylene as Automotive Fuel (Azetylen als Motor benstoff), R. Lutz. Motorwagen (Berlin), vol. 31, nos. 32 and 34, Nov. 20 and Dec. 10, 1928, pp. 776–783 and 826, 13 figs. Nov. 20: Tests with acetylene without fluid injection, and tests with water and alcohol injection. Dec. 10: Comparison of water and alcohol as injection medium; tests with gasoline injection; comparison between alcohol and gasoline injection.

Alcohol, Synthetic. The Alcohols, R. H. Hopkins. Times Trade and Eng. Supp. (Lond.), vol. 23, no. 542, Nov. 24, 1928, pp. 34–35, 3 figs. High-pressure synthesis; British Empire's resources; Swiss experience; search for suitable catalyst; lacquer solvents.

Anti-Knock Testing. Audibility Spark-Advance Anti-Knock Tests, D. Roesch. Armour Engr., vol. 19, no. 4, May 1928, pp. 132–133 and 156, 6 figs. Some engine or fuel characteristics which are determined before conducting routine audibility spark-advance anti-knock tests in Automotive Laboratory of Armour Institute of Technology; mixture ratio; effect of mixture ratio on knock index; determining benzol equivalent.

Gasoline Substitutes. Substitutes for Petrol, W. R. Ormandy and A. Metral. Modern Transport (Lond.), vol. 20, nos. 509 and 510, Dec. 15 and 22, 1928, pp. 9 and 16. Dec. 15: Gas producers and Diesel engines for road vehicles are taken up; W. R. Ormandy discussed kerosene as substitute fuel produced by high and low-temperature distillation of coal; A. M. Metral discussed gas producers, carbonite, and Diesel engines. Dec. 22: Discussion of papers. Abstracts of papers presented before joint meeting of Inst. of Transport and Inst. of Fuel. For abstract of W. R. Ormandy's paper see also Elec. Ry., Bus and Tram Jl., vol. 59, no. 1483, Dec. 14, 1928, pp. 428, 430, 432, 434.

B

BEARING METALS

Bronze, Testing. Wear and Mechanical Properties of Bearing Bronzes, H. J. French, S. J. Rosenberg, W. LeC. Harbaugh and H. C. Cross. Rolling Mill Jl., vol. 2, no. 12, Dec. 1928, pp. 535–536. Bronzes were tested under rolling sliding friction without lubricants, at atmospheric and elevated temperatures up to 350 deg. fahr., in presence of oil, and in presence of abrasives at atmospheric temperatures, and under tension, impact, and pounding at temperatures from 70 to 600 deg. fahr. Abstract of U. S. Bur. of Standards—Research paper, no. 13.

BELT DRIVE

Research. Power Transmission by Belts, H. W. Swift. Machy. Market (Lond.), nos. 1466, 1467, and 1468, Dec. 7, 14 and 21, 1928, pp. 1125–1126, 1149–1150, and 1175–1176. Dec. 7: Present state of knowledge of principles underlying belt transmission; mechanics of slip and creep; creep tests; conditions of general slip. Dec. 14: Running characteristics cannot be determined and compared from other than running tests; operation at constant mean tension and at constant center distance; free belt. Dec. 21: Condition of constrained belt; summary of results. Abstract of paper read before Instn. Mech. Engrs.

Slipping. Slip in Belt Transmission, T. Nishihara. Soc. Mech Engrs.—Jl. (Tokyo), vol. 31, no. 138, Oct. 1928, pp. 937–953, 16 figs. Expressing coefficient of friction as function of sliding velocity and taking into consideration slipping velocity of belt due to its elasticity, distribution of belt tension on pulley surface and slips in belt transmission are found; maximum load transmitted without sliding slip is determined. (In English.)

BLAST FURNACES

Dovel Type. Dovel Type Blast Furnace Put on Test, J. P. Dovel. Blast Furnace and Steel Plant, vol. 16, no. 12, Dec. 1928, pp. 1555–1558 and 1570, 2 figs. Design and operation of improved Dovel-type blast furnace, with double skip-filled McKee top and stack equipped with nine rows of Dovel inwall cooling blocks, principal object of design being the production of flue dust; furnace at one of large Southern iron and steel plants is operated for six days on burden of crushed ore; procedure stimulates northern practice; results of test are given.

BLOWERS

New Types. New Scavenge Air Blowers (Neuere Spuelluftgeblaese), B. Eck. Werft-Reederei-Hafen (Berlin), vol. 9, no. 18, Sept. 22, 1928, pp. 373–375, 6 figs. Various recent blowers made by F.M.A. are described; they are of single-stage spiral impeller type, impeller drawing from each side; plans, photographs, and test data illustrate their general features; particular attention given in design to elimination of noise, accomplished by omission of usual fixed guide blades, and by design of suction chamber. See brief translated abstract in Mar. Engr. and Motorship Bldr. (Lond.), vol. 51, no. 616, Dec. 1928, p. 472.

BOILER FURNACES

Bituminous-Coal. Boiler Furnaces for Bituminous Coal, A. G. Christie. Combustion, vol. 20, no. 1, Jan. 1929, pp. 30–36. Certain features of these furnaces discussed and probable trend of development indicated; combustion problem; furnace walls; preheated air; furnace volumes; water-cooled furnace walls; slag on boiler tubes; stoker development; developments in pulverized-coal furnaces; automatic combustion control. Paper presented at Int. Conference on Bituminous Coal.

Pulverized-Coal. New Methods and Aims of Pulverized-Coal Firing (Neue Wege und Ziele der Kohlenstaubfeuerung), Wintermeyer. Feuerungstechnik (Leipzig), vol. 16, nos. 23 and 24, Dec. 1 and 15, 1928, pp. 265–267, and 279–283, 8 figs. Rapidly growing significance and utilization of pulverized-coal firing are pointed out; notes on fuel preparation; unit vs. central pulverizers; combustion problems; design of boilers; increasing the operating safety of pulverized-fuel plants; protection against explosions; economy of pulverized-coal firing.

BOILER TUBES

Arc Welding. Arc Welding Boiler Tubes, G. H. Clark. Welding Engr., vol. 13, no. 12, Dec. 1928, pp. 57–58, 4 figs. Methods which have been developed to eliminate some of common troubles encountered in locomotive and stationary boiler maintenance; example of efficiency of new method of taking care of boiler-tube troubles.

BOILERS

Drums, Manufacture of. The Manufacture of Riveted Drums for Large Boilers. Engineering (Lond.), vol. 126, no. 3282, Dec. 7, 1928, pp. 722–724, 4 figs. Account of methods and equipment of Babcock and Wilcox at Renfrew, where plant has been installed for constructing riveted boiler drums up to 40 ft. long and 2 1/4-in. thick.

Heads, Design of. Notes on Curved Bottoms Established from Experiences of the Kaiser-Welhelm Institut (Notes sur les fonds bombés établiés d'après les expériences du Kaiser-Wilhelm Institut), H. Tulcinsky. Annales de l'Association des Ingénieurs Sortis des Écoles Spéciales de Gand (Ghent), vol. 18, series 5, no. 3, 1928, pp. 327–336, 4 figs. Theoretical discussion of shapes of curved boiler heads or tank bottoms with and without manholes and strains in such heads.

BRONZE

Forging. Forging Bronze Permits Intricate Hand Work. Brass World, vol. 24, no. 12, Dec. 1928, p. 373, 1 fig. Description of new material called Anaconda forging bronze, which American Brass Co., Waterbury Conn., has placed on market, for architectural decoration and other purposes; from lowest perceptible red heat through many temperatures to extreme bright red, Anaconda forging bronze was found to forge well.

C

CARBURETORS

Testing. Theoretical Investigation on a New Carburetor, M. Isikawa. Soc. Mech. Engrs.—Jl. (Tokyo), vol. 31, no. 136, Aug. 1928, pp. 726–743, 8 figs. New carburetor consists of choke tube of Venturi type and fuel diffuser, diamond-shaped in section, which is substitute for fuel-spray nozzle of simplest jet-in-tube carburetor; throttle valve, as usually adopted in other carburetors, may be entirely dispensed with; analytical investigation on air flow through this carburetor. (In English.)

CARS

Journal Bearings for. Development of the Isothermos Journal Box, L. Hall. Commerce Reports, no. 1, Jan. 7, 1929, pp. 20–21, 2 figs. Isothermal journal bearing is proving one of most successful developments in Europe; operation of isothermos journal; special provision for surplus oil circulation; isothermos bearings widely distributed in use; list of various railroads throughout Europe, Africa, and elsewhere now using these self-lubricating journal boxes.

CASE HARDENING

Nitriding Process. Nitration of Steel With Ammonia Gas Under Pressure, R. H. Hobrock. Fuels and Furnaces, vol. 6, no. 12, Dec. 1928, pp. 1681–1682. Nitriding with increased pressure of ammonia gas results in decrease in surface hardness but in increase in depth of case. Abstract of paper presented before Am. Soc. Steel Treating, previously indexed from preprint.

Surface Hardening of Steel With Nitrogen, F. L. Coonan. Heat Treating and Forging, vol. 14, no. 12, Dec. 1928, pp. 1400–1401, 3 figs. Technique of nitriding process is described along with steel composition adaptable to such treatment; box or tube furnace used for nitriding; proper arrangement of ammonia tank is of great importance in securing uniform running conditions; furnace is heated above decomposition temperature of ammonia; advantages of process; case is extremely hard and is obtained without any subsequent heat treatment; no change in dimensions or warping during process; case shows remarkable resistance to wear and corrosion.

CASTING

Centrifugal. A Notable Foundry. Iron and Steel Industry (Lond.), vol. 2, no. 3, Dec. 1928, pp. 69–71, 3 figs. Centrifugal casting department of Thorncliffe Iron Works of Newton and Chambers and Co., is described; two large cupolas and one small experimental cupola; production of piston-ring drums and cylinder liners; discovery of means whereby low-silicon low-total-carbon-content material can be cast by centrifugal casting process; Hurst-Ball machine.

CASTINGS

Internal Stresses. Internal Stresses, A. Le Thomas. Foundry Trade Jl. (Lond.), vol. 39, no. 642, Dec. 6, 1928, pp. 414–415, 2 figs. Suppression of internal stresses in castings; table given shows results obtained on rough-cast test pieces reheated to different temperatures, with corresponding shearing test values and Brinell hardness; responsibility incurred by founder in regard to stresses causing apparently spontaneous rupture. Paper presented to Paris Foundry Congress.

CHAINS

Wrought Iron, Failure of. The Causes of Failure of Wrought-Iron Chain and Cable, H. J. Gough and A. J. Murphy. Instn. Mech. Engrs.—Proc. (Lond.), no. 2, 1928, pp. 293–326 and (discussion) 327–352, 29 figs. Failures and characteristics of overheated wrought iron; failures due to faulty welds or to welds which have deteriorated in service; series of experiments made to study effect of repeated static straining; investigation of properties of various wrought-iron chains drawn from service of known history; conclusions drawn from results of research.

COAL PULVERIZERS

Unit, Sampling from. Accurate Sampling From Unit Pulverizers, P. A. Willis. Power, vol. 68, no. 25, Dec. 18, 1928, pp. 1003–1004, 4 figs. In order to keep check on performance of pulverizer, it is necessary to obtain frequent samples of pulverized coal to test for fineness and moisture; in actual tests writer has found that percentage of particles that will pass through 200-mesh sieve may be made to vary as much as 100 per cent by merely varying suction on sampling tube; arrangement is described by which accurately representative samples may be taken.

CONVEYORS

Chain. The Redler Conveyor. Indus. Mgmt. (Lond.), vol. 15, no. 12, Dec. 1928, pp. 408–410, 5 figs. Redler conveyor will handle almost any kind of bulk material; occupies less room and consumes less driving power than most other types; power required is calculated by formula; shows great saving of power especially in case when compared with worm conveyor.

Power Plants. Power Plants Utilize Many Types of Conveyors. Power Plant Eng., vol. 33, no. 1, Jan. 1, 1929, pp. 7–11, 10 figs. Discussion of use and advantages of various types, with details of their applications to varying plant conditions; influence of storage facilities on conveyors; capacities of bucket elevators; uses of pivoted bucket conveyor; drag and flight conveyors; screw or spiral conveyors; use of belt conveyors and their capacity and speeds; feeders for conveyors; pneumatic methods for handling coal; conveyor drives.

Roller. Using Roller Conveyors to Serve Machines. Am. Mach., vol. 69, no. 25, Dec. 20, 1928, pp. 962–963, 6 figs. Roller conveyors used in transporting washing-machine parts from one operation to another are shown in six halftones furnished by Standard Conveyor Co., each halftone accompanied by brief description.

CORE OVENS

Continuous. Speeds Core Baking With Continuous-Type Oven, F. G. Steinebach. Foundry, vol. 56, no. 24, Dec. 15, 1928, pp. 1008–1012, 5 figs. Continuous-type oven used by Packard Motor Car Co. for baking cores is described; oven is 100 ft. long and 40 ft. high; baking compartment is of double vertical type; gas used for fuel; 64 racks carried on chain; oven used to dry blackened and pasted cores of vertical lift type; every step of core assembly studied carefully; assembly outlined.

COST ACCOUNTING

Depreciation. How to Handle Depreciation Accounting on the Books, T. B. Frank. Am. Mach., vol. 69, no. 26, Dec. 27, 1928, pp. 997–999. Discussion includes method of reconciling procedure required to meet income tax regulations with that of securing figures needed for guidance of management; depreciation computed on current replacement values has distinct advantage when used from cost angle.

COUPLINGS

Flexible, Fatigue in. What Happens in Couplings; Fatigue of Materials; What It Is and How It Occurs in Flexible Couplings, H. F. Moore. Iron and Steel Engr., vol. 5, no. 12, Dec. 1928, pp. 513–517, 8 figs. Fatigue of metals discussed; dangerous effect of reversing stresses due to misalignment of shafting; function of flexible coupling; table gives fatigue limit and energy storing capacity for various metals; coupling with flexible materials eliminated; Fast's coupling developed on floating-sleeve principle with oil as load-carrying agent.

CRANES

Modern Types. Modern Lifting Machinery. Mech. World (Manchester), vol. 84, nos. 2180, 2186 and 2189, Nov. 23 and Dec. 14, 1928, pp. 367–369, 484–486 and 560–563, 19 figs. Oct. 19 Construction and operation of semi-portal cranes; cranes equipped with Craven patent level luffing gear; Stothert and Pitt semi-portal cranes. Nov. 23: Portal wharf cranes are entirely self contained, and have greater hoisting range being mounted on high gantry under which one or more lines of railway allow movement of rolling stock beneath crane; details of 3-ton Royce wharf crane, Stothert and Pitt portal cranes, and Topliss luffing gear. Dec. 14: Various types of bridge unloaders and transporters are described; 30-cwt. Barry transporter; 6 1/2-ton Royce transporter; operation of 25-cwt. electric double-track transporter installed at Fleetwood fish docks by Cowan, Sheldon and Co., Carlisle.

CUPOLAS

Design. The Calculation of the Useful Height of a Foundry Cupola, M. Karnaoukhov. Iron and Steel Industry (Lond.), vol. 2, no. 3, Dec. 1928, pp. 83–85. Important theoretical considerations involved in cupola design; new method of calculation of useful height of cupola based on nature of heat distribution within cupola; sensible heat losses calculated; general heat balance during four hours of work; formula constant when working conditions remain constant; advantages and disadvantages of increasing cupola height.

Practice. Melting Iron in the Cupola, J. E. Hurst. Foundry, vol. 56, nos. 23 and 24, Dec. 1 and 15, 1928, pp. 972–975 and 1013–1016, 19 figs. Dec. 1: Methods of handling and charging materials into cupola; equipment ranges from simple jib crane depositing charge on scaffold to elaborate system of crane, magnet and bucket handling materials at every stage. Dec. 15: Many types of charging equipment for cupola; crane or monorail system utilized between charging periods in unloading pig iron and scrap with magnet, limestone, coke and sand with bucket; magnet employed in hoisting drop ball for breaking scrap.

D

DIESEL ENGINES

Automotive. Automotive Diesel Engines of the Deutz Motor Works (Fahrzeug Dieselmotor der Motorenfabrik Deutz A. G.), L. Hausfelder. Motorwagen (Berlin), vol. 31, no. 33, Nov. 30, 1928, pp. 806–810, 8 figs. Details of high-speed heavy-oil engine for use in motor boats and for cranes, excavators, road machinery, and plows, but designed particularly for motor trucks; it is vertical 4-stroke engine of ante-chamber design and is constructed with 4 or 6 cylinders, bore 115 mm., stroke 170 mm.

Design. Progress in Design and Construction of Diesel Engines (Neuerungen in Fertigung und Konstruktion von Verbrennungsmotoren), Schulz. Werft-Reederei-Hafen (Berlin), vol. 9, no. 20, Oct. 1928, pp. 414–415, 4 figs. Author deals principally with experience of Deutz, whose output of Diesel engines is greatest in Europe; high-speed Diesel demands rigid construction free from vibration, first-class lubrication, completely enclosed crankcase, and absolute control of combustion; progress in design demands similar progress in methods of manufacture and testing. See brief translated abstract in Mar. Engr. and Motorship Bldr. (Lond.), vol. 51, no. 616, Dec. 1928, p. 473.

Explosions in. Probable Causes of Explo-

sions in Diesel Engines. F. W. Williams. Power, vol. 68, no. 25, Dec. 18, 1928, p. 1011. Author claims that they generally originate at local spot and cause can generally be traced to some section with fault in design or extremely careless operation; in the main, however, serious explosions in Diesel engines are rare, and as designs become perfect, their chances of happening are constantly becoming less.

Supercharging. Tests on a Diesel Engine with Buechi Turbo-Blower Feed (Essais effectués sur un moteur diesel alimenté par turbo-souffiante suivant le procédé Buochi), Stodola. Bul. Technique du Bureau Veritas (Paris), vol. 10, no. 11, Nov. 1928, pp. 207–210, 7 figs. Résumé of report on tests made at Winterthur, Switzerland, by Sociéte Suisse pour Construction de Locomotives and Brown-Boveri: description of installation and results of tests worked out.

E

ELECTRIC FURNACES

Annealing. Electric Blank Annealing Furnaces (Elektrische Blankgluehoefen), H. Langenbach. Elektrizitaetswirtschaft (Berlin), vol. 27, no. 471, Nov. 2, 1928, pp. 571–574, 6 figs. Author criticizes commercial annealing furnaces; proposes design of electric annealing furnace based on experimental study; electrification of old coal-burning furnace.

Heat Treating. New Electric Furnaces for Steel Treatment, W. B. Hall. Yale Sci. Mag., vol. 3, no. 1, Nov. 1928, pp. 15–16, 2 figs. Revolutionary change in hardening of high-speed steel brought about by development of new type of electric furnace; short description of use of high-speed steel in industry; difficulties encountered in hardening steel; new way of heating steel which offers complete protection to work against oxidation.

Steel Melting. Electric Melting of Alloy Steels, H. M. German. Iron and Steel Engr., vol. 5, no. 12, Dec. 1928, pp. 507–510. Stassano, Kjellin, Heroult, and Girod electric furnaces described in historical sketch; growth of electric steel industry in United States; cold melting practices with complete, partial, and no oxidation; selection of method governed by analysis of available charging materials; refining slags; temperature of metal before tapping. Paper presented before Industrial Heating Conference at Penn State College.

ELECTRIC WELDING

Arc, Brass and Bronze. Arc Welding Brass and Bronze, R. H. Davis. Welding Engr., vol. 13, no. 12, Dec. 1928, pp. 53–54. Frequent demand for repairs in place have led to development of technique for using carbon arc with bronze filler rod in naval work; description of some of work accomplished and methods used in welding of brass and bronze by arc in U. S. Navy Yard, Puget Sound.

Costs. Welding Costs Are Reduced by Use of Larger Electrodes, C. J. Bowers. Iron Trade Rev., vol. 83, no. 25, Dec. 20, 1928, pp. 1564–1565, 2 figs. Definite relationship established between sizes of electrodes and savings effected; time studies made of welding operations.

F

FANS

Types. Fan Types and Applications, H. F. Hagen. West Soc. Engrs.—Jl., vol. 33, no. 12, Dec. 1928, pp. 605–614, 4 figs. Statement of principles governing selection of type of fan for particular kind of service; curves given show performance of each type; shows how these principles were applied in selection of fans for ventilating Holland tunnel in New York.

FORGING

Bronze for. See BRONZE.

FORGING MACHINES

Repetition Work. Forging Machine for Repetition Work. Engineer (Lond.), vol. 146, no. 3801, Nov. 16, 1928, p. 556, 2 figs. Universal forging machine made by B. and S. Massey is driven by electric motor mounted on framing, making very compact unit accessible from all sides; it is capable of dealing with smiths' work of all kinds usually done under steam or power hammer of 10 to 15 cwt. sizes.

FORGINGS

Drop and Machine. Drop Forgings and Machine Forgings, F. W. Spencer. Metal Industry (Lond.), vol. 33, no. 22, Nov. 30, 1928, pp. 517–518 and (discussion) 518. Paper discusses drop hammers, dies and trimming tools, upsetting machine, and forging operations and procedure; forging motor-car front axle; uses of upsetting machines. Abstract of paper presented before Coordinating Committee.

Some Notes on the Quality of Upset Machine Forgings, E. R. Frost. Can. Machy. (Toronto); vol. 39, no. 26, Dec. 27, 1928, pp. 202–205, 20 figs. Upsetting of steel in forging machines is discussed, results of tests and photomicrographs are given to show endwise working of material places grains in closer endwise formation; other tests described; table of average elastic limit, ultimate strength elongation, and reduction of area; no evidence exists to indicate any unsatisfactory results through upsetting on any alloy steels or non-ferrous metals. Paper presented before Am. Soc. for Steel Treating.

FOUNDRIES

Automobile Plants. Chevrolet Foundry in Saginaw, Mich., of General Motors Corp. (Die Chevrolet-Giesserei in Saginaw, Mich., Div. der General Motors Corporation), F. E. Gruetzmacher. Giesserei (Duesseldorf), vol. 15, nos. 46 and 47, Nov. 16 and 23, 1928, pp. 1150–1157 and 1173–1182, 45 figs. Discussion of labor and operating conditions; new molding machine is described, made by Osborne Mfg. Co., which is used for engine ingots and delivers 350 boxes in 10 hr.; coremaking; cleaning; melting; future foundry design and practice.

FURNACES

Annealing, Continuous. Double Deck Conveyor Furnaces Used in Annealing Stampings. Fuels and Furnaces, vol. 6, no. 12, Dec. 1928, pp. 1655–1657, 3 figs. Oil-fired furnaces, of continuous conveyor hearth type in which product is heated in upper chamber and cooled in lower chambers, are used for annealing of automobile front-wheel hub stampings between drawing operations.

G

GAGES

Manufacture. Manufacture of Wickman Gauges. Machy. (Lond.), vol. 33, no. 842, Nov. 29, 1928, pp. 257–262, 12 figs. Methods employed by Coventry Gauge & Tool Co. for manufacturing Wickman gages are described; Wickman gage details; operations on frame; drilling holes for anvils; seasoning process; sizing anvil holes.

GAS PRODUCERS

Design. Some Aspects of the Working of Internal Producers, With Suggestions for Improved Efficiency, F. C. Sylvester. Gas Jl. (Lond.), vol. 184, no. 3418, Nov. 21, 1928, pp. 537–539. One of most likely means of effecting reduction in amount of heat lost is introduction of better designed step-grate producers with intelligent control; points which are most likely to bring about ideal conditions are: exposure of as large a fuel area as possible, time contact of fuel and air to be as long as possible, maintenance of highest temperature possible in producer consistent with ash of fuel being discharged as dust and not as clinker. Paper presented before Midland Junior Gas Assn.

GASES

Detonation of. Theory of Detonation, G. Nakanishi. Soc. Mech. Engrs.—Jl. (Tokyo), vol. 31, no. 136, Aug. 1928, pp. 711–725, 11 fig. Object of this paper is to explain why and how detonation occurs, treating it as physical phenomena caused by heat emission; limit of slow steady propagation of flame; velocity of detonation; velocity of gas in detonation. (In English.)

GEARS

Friction. Loss of Power, Deformation, and Backlash in Rolling of Driving and Braked Wheels and Disks (Arbeitsverlust, Formaenderungen und Schlupf beim Rollen von treibenden und gebremsten Raedern oder Scheiben), H. Fromm. Zeit. fuer Technische Physik (Leipzig), no. 9, Sept. 1928, pp. 299–311, 7 figs. Report from mechanical laboratory of Berlin Institute of Technology; theoretical mathematical analysis of friction gears, and general laws of dynamic friction; also numerical example.

Worm, Lubrication of. Lubricating Worm Gears, W. E. Warner. Power, vol. 68, no. 25, Dec. 18, 1928 p. 1006. Brief account of experiments carried out by British National Physical Laboratory to determine efficiency of worm-gear lubricants; addition of small amount of fixed oil (non-drying vegetable oil) to ordinary mineral oil was found to be beneficial.

H

HAMMERS

Electric. Construction and Application of Weinaf Hammers. (Weinafhammarens Konstruktion och anvandnings-omraden), W. Weibull. Teknisk Tidskrift (Stockholm), vol. 58, no. 50, Dec. 15, 1928: (Mekanik), pp. 153–156, 4 figs. Account of elaborate investigation, theoretical calculations, and experimental work by A. B. Nordiska Armatur Fabrikerna; description of tool and formula for calculation of blow effect.

HEAT TRANSMISSION

Laws of. The Radiation and Convection of Heat, T. Barratt. Inst. of Fuel—Jl. (Lond.), vol. 1, no. 4, July 1928, pp. 396–401 and (discussion) 401–403, 3 figs. Theoretical knowledge of laws of transfer of heat is very necessary in design of water-tube boilers; laws of radiation and convection; experimental; applications to practical engineering problems; transmission of heat in water-tube boilers. Paper read before Instn. of Fuel Economy Engrs. Bibliography.

Liquids in Pipes. Heat Transmission in Flowing Liquids in Tubes (Waermeuebergang Stroemender Fluessigkeit in Rohren), L. Schiller and T. Burbach. Physikalische Zeit. (Leipzig), vol. 29, no. 11, June 1, 1928, pp. 340–342, 2 figs. After review of work of Reynolds, Prandtl, Taylor and Karman, authors discuss work of Nusselt; further equation is developed as limiting case of Nusselt expression; this equation is in agreement with experimentally determined values for water.

Still Air. Experimental Study of Heat Transfer in Air at Rest (Versuche ueber den Waermeuebergang in ruhender Luft), E. Schmidt. Zeit. fuer die gesamte Kaelte-Industrie (Berlin), vol. 35, no. 11, Nov. 9, 1928, pp. 213–219, 10 figs. Paper read at 1928 annual meeting of German Refrigeration Society Kaelteverein; details of experiments at mechanical laboratory of Danzig Institute of Technology on heat transfer from ice blocks and metallic plates.

HYDRAULIC TURBINES

Francis. Progress in Construction of Hydraulic Turbines (Fortschritte Im Bau von Wasserturbinen), Oesterlen. V.D.I. Zeit. (Berlin), vol. 72, no. 48, Dec. 1, 1928, pp. 1741–1748, 20 figs. General review of recent improvements in design of blades, runners and other parts of Francis turbines in Europe and America; value of experiments with models; details of Voith and other designs of Francis high-head, high-speed turbines; recent low-head turbines with spur-gear drive.

Propeller Type. Aerofoil Theory of Propeller Turbines and Propeller Pumps With Special Reference to the Effects of Blade Interference Upon the Lift and the Cavitation, F. Numachi. Soc. Mech. Engrs.—Jl., (Tokyo), vol. 31, no. 136, Aug. 1928, pp. 530–538, 4 figs. Writer has deduced theory of these machines in light of theory of airfoil; preliminary study of theory of blade interference; theory of propeller turbines and of propeller pumps. (In English.)

Theory and Design of a Propeller Turbine, O. Miyagi. Soc. Engrs.—Jl., vol. 31, no. 136, Aug. 1928, pp. 607–615, 4 figs. Forms of casing and hub are first given, and streamline forms in clearance space are determined by making use of cylindrical coordinates; inflow velocities into runner are then calculated from streamline and entrance and exit forms of runner vanes, to satisfy condition of minimum hydraulic losses, are determined; expressions for developing moment and power are deduced; graphical solution is introduced. (In English.)

HYDRODYNAMICS

Fluid Resistance. Resistance of Spheres and Disks at Low Reynolds Coefficients (Widerstandsmessungen and Kugel und Scheibe bei kleinen Reynolds-schen Zahlen), L. Schiller and H. Schmiedel. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 19, no. 21, Nov. 14, 1928, pp. 497–501, 9 figs. Description of apparatus; results of experimental study confirming deduction of Oseen theory.

INDUSTRIAL MANAGEMENT

Automobile Plants. Keeping Machines and Power on the Job, H. A. Zannoth. Mfg. Industries, vol. 16, no. 8, Dec. 1928, pp. 579–582, 5 figs.

Methods under which 2800 machines were moved during year at plant at Cadillac Motor Car Co.; 1000 plant betterments handled in two weeks, maintenance costs reduced, and interruptions to production cut down.

Cost Reduction. Practical Ways to Cut Costs. Factory and Indus. Mgmt., vol. 77, no. 1, Jan. 1929, 7 figs. Experiences of nine manufacturers are cited; daylight at low cost; burning off dirt; cutting loading costs; ramp speeds handling; where group drive pays; tractor replace 42 men.

Maintenance Departments. Cutting Costs of Maintenance Department Through the Application of Scientific Management, R. R. Rees. Soc. Indus. Engrs. Bul., vol. 10, no. 11, Nov. 1928, pp. 3–11, 4 figs. To manage maintenance department properly definite plan must be developed, to consist of proper organization and satisfactory scheme for cost control; necessary that construction work in industrials be combined with maintenance and that maintenance engineer be alert as to cost of various projects for which he is responsible, that he be in position to lower costs of maintenance each year through better management and by taking advantage of improved development of equipment, machinery and materials.

Production Planning. Production Problems, B. C. Jenkins. Automobile Engr. (Lond.), vol. 18, no. 249, Dec. 1928, pp. 500–502. Work of demonstration and investigation staff in understanding and linking up planning department and production sections is discussed; functions of planning; analysis of component design; planning operation sequences; design of special equipment; demonstratation of equipment and process; cylinder tolerances; shop investigations; demonstration of new machines. Abstract of paper presented before Instn. Production Engrs.

Time Study. Relation of Time Study to Manufacturing, L. W. Haskell. Metal Stampings, vol. 1, no. 7, Dec. 1928, p. 510. Time study used as basic unit of measurement for items such as machine loads, labor control, cost estimates, budgets, wage incentives, etc. Abstract of paper presented at Production Meeting of Soc. Automotive Engrs.

I

INDUSTRIAL PLANTS

Materials Control. The Systematic Control of Material. Machy. (Lond.), vol. 33, no. 846, Dec. 27, 1928, pp. 416–418, 3 figs. Functions of materials-control department; meeting requirements from stock; following up material orders; two charts used as basis of following up activities; expediting delivery of material required by personal visits; store must not be filled with unwanted stocks.

INSULATING MATERIALS (HEAT)

Conductivity of. Methods of Measuring the Thermal Conductivity of Insulating and Refractory Materials, M. L. Hartmann, O. B. Westmont and C. E. Weinland. Ceramic Age, vol. 12, no. 6, Dec. 1928, pp. 225–233 and 248–250, 21 figs. Series of thermal conductivity measurements was carried out to investigate methods that might be used as standard tests; apparatus used; methods are described; experimental results are given. Paper presented before Am. Soc. Testing Matls.

INTERNAL-COMBUSTION ENGINES

Efficiency Determination. The Determination of Standard Efficiencies of Internal-Combustion Engines by the Energy Chart, W. J. Goudie. Engineering (Lond.), vol. 126, no. 3281, Nov. 30, 1928, pp. 695–698, 11 figs. Author submits development of energy-chart method which takes account of effect on ideal efficiency of fuel composition, air-fuel ratio variation of specific heat, and dissociation of products at high temperatures which is supposed to occur in gasoline and alcohol engines; for each class of fuel standard chart can be drawn and from it close approximation to ideal or standard efficiency of comparison of particular cycle employed can easily be and quickly obtained. Abstract of paper red before Brit. Assn.

Cycle. The Hult Gas Engine Cycle. Power, vol. 68, no. 25, Dec. 15, 1928, p. 999, 1 fig. New cycle for internal-combustion engines has been invented by O. W. Hult, Aktiebolaget Archimedes, embodying novel plan of cooling air-charge; cycle gives denser air charge, permitting burning of more fuel per stroke.

Turbo-Compressor. Phenomena in an Internal-Combustion Engine With Exhaust-Gas-Turbine Precompressor (Darstellung der Vorgaenge in einem Verbrennungsmotor mit Abgasturbinen-Vorverdichter im pv-Diagramm), Schmolke. Waerme (Berlin), vol. 51, no. 50, Dec. 15, 1928, pp. 911–913, 6 figs. Diagram is developed for engine equipped with exhaust-gas turbine for drive of air compressor; and use of entropy tables to demonstrate phenomena occurring in these engines is explained.

[See also AIRCRAFT ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

IRON ALLOYS

Thermal Expansion of. Thermal Expansion of Iron Alloys (Ueber die thermische Ausdehnung von Eisenlegierungen), A. Schulze. Zeit. fuer Technische Physik (Leipzig), no. 9, Sept. 1928, pp. 338–343, 8 figs. Report from Germany's State Institute of Engineering Physics; data on thermal expansion of iron-silicon, iron-aluminum, and iron-manganese alloys up to 500 deg. cent.

IRON CASTINGS

Blast-Furnace Production. Blast Furnace Metal for Castings, D. Baker. Iron Age, vol. 122, no. 24, Dec. 13, 1928, pp. 1501–1502. Question of whether blast furnace can compete with pipe foundry is discussed; analysis of conditions and costs involved; two 10-hr. shifts a day in foundry recommended; foundry-equipment savings; unit costs tied up with quantity; use of direct blast-furnace metal for production of castings never tried commercially; advantage from mixing iron; qualities required by foundry; fluid iron can be made.

IRON FOUNDRIES

Practice. Melting Plant and Appliances in Modern Iron Foundries, J. McLachlan and C. A. Otto. Iron and Steel Industry (Lond.), vol. 2, no. 3, Dec. 1928, pp. 91–94, 5 figs. Design of charging platforms and hoists, considerations which have profound influence on economy, is discussed; protected staging for melting unit; mixtures and methods of charging; cupola plant in German foundry; relative merits of hand and automatic charging.

L

LIGHTING

Factory. Increased Illumination Pays for Additional Foot-Candles, M. Luckiesh. Elec. World, vol. 92, no. 24, Dec. 15, 1928, p. 1206. Factory tests, under levels of illumination up to 20 or 25 foot candles, indicate that increase in production results from increase in level of illumination; tests also show that value of increase in production resulting from moderate increase of illumination equals appreciable part of payroll.

Machine Shops. Modern Machine Shop Lighting, F. A. Hansen. West. Machy. World, vol. 19, no. 12, Dec. 1928, pp. 518–520 and 524, 6 figs. Details of lighting installation in shop and material yard of Doheny-Stone Drill plant, saw-tooth roof admitting daylight through sloping glass windows; requirements of lighting installation; light reflected by walls and machinery; aluminum interior finish.

LOCOMOTIVES

Articulated. World's Largest Locomotive Built for the Northern Pacific. Ry. Age, vol. 85, no. 26, Dec. 29, 1928, pp. 1295–1301, 11 figs. Single-expansion articulated 2-8-8-4 type locomotive; develops tractive force of booster at starting of 13,400 lb.; four cylinders have same diameter and stroke, 26 in. by 32 in.; firebox has three doors; table of dimensions, weights and proportions; arrangement and design of steam piping is one of features in design of locomotive.

Canadian Pacific. Largest Locomotives in the British Empire. Modern Transport (Lond.), vol. 20, no. 505, Nov. 17, 1928, p. 7, 3 figs. Details of two of new class of locomotives No. 3100 and 3101, completed by Canadian Pacific Railway at Angus Shops at Montreal; locomotives have maximum effort of 60,800 lb. and are capable of hauling train of from 18 to 20 loaded passenger coaches at express speed.

Design. An Analysis of the Design of Crosshead Guides, C. H. Faris. Ry. Mech. Engr., vol. 102, no. 12, Dec. 1928, pp. 681–682, 2 figs. Proposed method of determining normal loading, stresses and deflections is discussed; load due to rod thrust; conditions of usual practice in design of guides; typical results obtained from investigation of six classes of locomotives; method of support important factor in calculations; graphical analysis.

The Trend of Modern Steam-Locomotive Design, R. E. L. Maunsell. Instn. Mech. Engrs.—Proc. (Lond.), no. 2, 1928, pp. 465–473. Author discusses trend of steam-locomotive development in respect of size, type, and mechanical details and circumstances which influence these; considers briefly what attempts are being made throughout world to improve thermal efficiency of steam locomotive so that it may compare favorably with internal-combustion engine when mechanical difficulties of making latter suitable for railway locomotive have been overcome.

Diesel. A Heavy-Oil Engine Locomotive. Engineer (Lond.), vol. 146, no. 3802, Nov. 23, 1928, pp. 580–581, 4 figs. Details of small locomotive, fitted internal-combustion engine developed by Kerr, Stuart and Co.; outstanding feature is adoption of McLaren-Benz type of Diesel engine as propelling unit; it has four cylinders, 135 mm. bore by 200 mm. stroke, and develops 60 hp. when running at its normal speed; power is transmitted to gear box through simple cone clutch.

High-Pressure. An 850 Lb. Pressure Passenger Locomotive, H. Brown. Engineer, vol. 146, no. 3805, Dec. 14, 1928, pp. 655–658, 7 figs. Extracts from revised copy of paper read before Instn. Locomotive Engrs., with detailed description of locomotive built by Swiss Locomotive & Machine Works of Winterthur.

Wiesinger High-Power Locomotives (Hochleistungs Lokomotive Bauart Wiesinger), K. Wiesinger. Schweizerische Bauzeitung (Zurich), vol. 92, nos. 20 and 21, Nov. 17 and 24, 1928, pp. 249–252 and 263–267, 9 figs. Details of contruction and operation of high-pressure locomotive designed by author, weight 125 tons, 2000 hp., boiler temperature 470 deg. cent., pressure 43 atmos.; thermal efficiency referred to coal 15.5 per cent.

Oil-Electric. Oil Electric Locomotive, Canadian National Railway. Can. Ry. and Mar. World (Toronto), no. 370, Dec. 1928, pp. 731–732, 2 fig. Locomotive of two units will weigh 650,000 lb.; each unit contains 12-cylinder oil engine of solid-injection type 12-in. bore and 12-in. stroke; exhaust gases of oil engine are conducted to economizing boiler; traction motors are geared for passenger service and will develop 100,000 lb. tractive effort; locomotive will be capable of developing maximum tractive effort of 130,000.

2660-H.P. Oil-Electric Locomotive for the Canadian National Railways. Engineering (Lond.), vol. 126, no. 3283, Dec. 14, 1928, p. 756, 2 figs. Details of locomotive built by Wm. Beardmore and Co.; machine consists of two units, weighing together 290 tons, of which 214 tons are available for adhesion; each unit has one 12-cylinder engine and generator supplying current to four driving motors geared to axles; electric equipment designed by Westinghouse Electric and Manufacturing Co.

Research. New Methods and Results of Steam-Locomotive Research (Neue Versuchsmethoden und Versuchsergebnisse auf dem Dampflokomotive), H. Nordmann. Glasers Annalen (Berlin), vol. 103, no. 11, Dec. 1, 1928, pp. 137–146, 13 figs. Use of Riggenbach brake in locomotive testing; methods of determining mechanical efficiency, coal and steam consumption, etc., at velocities ranging from 49 to 80 km. per hour; train-resistance studies.

LUBRICATION

Theories of. Principles of Semi-Fluid Friction (Zu den Grundlagen der half-fluessigen Reibung), S. Kiesskalt. Zeit. fuer technische Physik (Berlin), vol. 9, no. 6, June 1928, pp. 207–212, 1 fig. Discussion of old and new literature relating to lubrication value hypotheses are developed with respect to molecular physical phenomena concerned; it is found from analytical data that different behavior of oils of equal lubrication value has nothing to do with surface tension toward air but is related to varying adsorption at metallic surfaces and dependence of viscosity on pressure; processes take place in boundary phase; technical importance of results is emphasized.

M

MACHINE TOOLS

Obsolescence. How Much of Your Equipment Is More Than Ten Years Old? Am. Mach., vol. 69, no. 25, Dec. 20, 1928, pp. 943–946. Graphic analysis of equipment in plant building steel mill equipment showing that 38 per cent of its plant machine equipment is more than 10 years old and that average length of service given by machines is 13.5 years; plant is well above average, yet charts show surprising number of machines in service 20 years or longer.

MAGNESIUM ALLOYS

Castings. Production and Properties of Magnesium Alloy Castings, E. Player. Metal Industry (Lond.), vol. 33, nos. 24 and 25, Dec. 14 and 21, 1928, pp. 568 and 570 and 591–592. Dec. 14: Paper is confined mainly to manufacture, properties and applications of magnesium alloy castings; composition of various Elektron alloys. Dec. 21: Physical properties of Elektron alloys; all magnesium alloys possess excellent machining qualities; use in foundry practice, as possible flux, and in molding and coremaking. Abridged from paper read before Co-ordinated Societies.

Automobile Plants. Unusual Material, Handling Systems Found in Automotive Plants. K. W. Stillman. Automotive Industries, vol. 59, no. 26, Dec. 29, 1928, pp. 948–949, 4 figs. Two mechanical handling installations in production of Willys Knight automobiles are described; continuous pouring installation is used in Wilson foundry; roller conveyors at Willys plant for radiator cores.

METALS

Endurance Testing. A Rapid Method of Determining Endurance Limit by Means of Measuring Electrical Resistance, S. Ikeda. Soc. Mech. Engrs.—Jl. (Tokyo), vol. 31, no. 136, Aug. 1928, pp. 447–466, 31 figs. Electrical resistance in steel specimens subjected to repeated bending stress was measured for different increasing stresses; relation between newly observed endurance limit and Shore's hardness number was shown. (In English.)

Hardening. Cold and Hot Working of Metals, W. Rosenhain. Metallurgist (Supp. to Engineer, Lond.), Nov. 30, 1928, pp. 168–169. Newer facts which have been revealed by modern systematic study of behavior of soft metals at room temperatures and of hard metals at high temperatures, serve as strong confirmation of proximate correctness of conception that ordinary "work hardening" is due to indirect effects of irregular layers produced by slip.

Machinability. Report on Machinability, E. G. Herbert. Engineer (Lond.), vol. 146, no. 3806, Dec. 21, 1928, pp. 692–695, 18 figs. Machining processes change physical properties of metals to which they are applied; machinability is not attribute of metals which can be considered or measured apart from particular machining processes; hardness of chips removed by metal-cutting process indicates hardness induced in metal by that process; original hardness of metals gives no indication of machinability; machinability depends on natural angles of built-up edge. Abstract of paper presented before Instn. Mech. Engrs. See also Engineering (Lond.), vol. 126, no. 3284, Dec. 21, 1928, pp. 789–792, 9 figs.

Temperature Effect. Electrical Behavior of Metals in the Neighborhood of the Temperature of Liquid Helium, W. Meissner. Information on Refrigeration (Institut International du Froid)—Monthly Bul., vol. 9, no. 3, May-June 1928, pp. 384–388. Boiling point of helium under normal pressure, at 760 mm. of mercury is 4.2 deg. abs.; measurements of electric resistance and thermal power of metals; it has not yet been possible to explain with certainty theory of superconductivity; measurements confirmed that ideally pure metals would have extremely low resistance in liquid helium, although this resistance is not incommensurably small. Translated from Zeit. fuer die gesamte Kaelte-Industrie, Nov. 1927.

The Stability of Metals at Elevated Temperatures, C. L. Clark and A. E. White. Univ. of Mich.—Eng. Research Bul., no. 11, Nov. 1928, 123 pp., 36 figs. Outstanding problems at present involved in used of metals at elevated temperatures; bulletin M after brief review of literature, gives account of method of investigation and statement of results obtained from short-time tensile tests and from expansion tests.

METHANOL

Synthesis of. Methanol From Hydrogen and Carbon Monoxide, R. L. Brown and A. E. Galloway. Fuel (Lond.), vol. 7, no. 12, Dec. 1928, pp. 518–525, 10 figs. Results of experiments by U. S. Bureau of Mines; brief review of results in Europe; gas used in these experiments has consisted of essentially two parts of hydrogen and one part carbon monoxide; catalysts were preparations of zinc oxide, basic zinc chromate, and normal zinc chromate which had been reduced. Bibliography.

MOLDS

Gates for. Gating Technology and the Weighting of Molds (Eingusstechnik und Belastung der Form), B. Osann. Giesserei (Duesseldorf), vol. 15, no. 49, Dec. 7, 1928, pp. 1217–1225, 26 figs. Formula is developed for determining pouring time based on purely theoretical principles; results of three investigations are given in which formula is subjected to practical tests and revised; temperature of molten iron is discussed; weighting of mold is developed theoretically.

MOTOR BUSES

Gasoline-Electric. Development and Operation of Gas-Electric Drive Motor Coaches, G. W. Wilson. Can. Ry. and Mar. World (Toronto), no. 370, Dec. 1928, pp. 741–742, 2 figs. Outstanding advantage of gas-electric drive motor coach as compared with other types is its ability to maintain from 10 to 20 per cent higher schedule speeds under extreme traffic condition; lower efficiency of electric transmission as compared with mechanical drive.

Steam. New Steam-Propelled Motor Bus Has Horizontal Boiler, P. M. Heldt. Automotive Industries, vol. 59, no. 26, Dec. 29, 1928, pp. 940–943, 5 figs. Details of steam coach with seating capacity for 27 in interurban and several more for urban service, which were developed by Delling Motors Co., Camden, N. J.; crosswise mounting of engine and combined fuel and water pump also features of Delling Coach; power plant has three cylinders and is of double-acting type, with bore 1/4 in. and stroke 4 1/4-in.; reciprocating balance weights; details of water and fuel pumps.

MOTOR TRUCKS

Brakes. Metal to Metal Brakes for Heavy Duty Trucks, T. Weber. Power Wagon, vol. 41, no. 285, Sept. 1928, pp. 38–39. Brief survey of development of brake design for heavy automotive equipment; for severe service, economy, and general reliability, external band-type brake with metal-to-metal friction is best.

MOTOR VEHICLES

Design. Horse-power, Load and Chassis Weight, L. M. Meyrick-Jones. Motor Transport (Lond.), vol. 47, no. 1239, Dec. 10, 1928, pp. 703–704, 5 figs. Some statistics to indicate how these three important design factors vary with vehicle size are given; comparative figures for motor-truck and bus chassis are taken from this magazine's Buyers' Guide.

Transmission Gears. Five-Speed Cotta Transmission Controlled by One Lever. Automotive Industries, vol. 59, no. 26, Dec. 29, 1928, pp. 934–935, 3 figs. Details of five-speed transmission for trucks and buses developed by Cotta Gear Co., Rockford Ill.; device of continuous-mesh type has all shafts arranged in same horizontal plane; control is by one lever; transmission is made in two models, one with direct drive on high, other with indirect overgeared fifth speed.

N

NITROCELLULOSE FINISHES

Properties and Uses. Nitrocellulose Finishes, B. Campbell. Indus. Chemist (Lond.), vol. 4, no. 47, Dec. 1928, pp. 522–526. Materials employed in nitrocellulose finishes and their essential properties; resins; softening agents; pigments; factors affecting durability of nitrocellulose finishes; evaluation of durability.

NOZZLES

Gas Expansion in. The Expansion of High-Temperature Gases in Nozzles, E. C. Wadlow. Instn. Mech. Engrs.—Proc. (Lond.), no. 2, 1928, pp. 405–415, 10 figs. Author describes experiments carried out to measure coefficients of velocity and of discharge, and heat losses, associated with two nozzles of simple form expanding high-temperature and high-pressure products of combustion of gaseous fuel; conditions identical with those occurring in internal-combustion turbines.

O

OIL ENGINES

Foundations for. The Installation of Gas and Oil Engines. Gas and Oil Power (Lond.), vol. 24, no. 279, Dec. 6, 1928, pp. 43–44, 3 figs. Construction of suitable foundations for gas and oil engines is described; engine foundation constructed on piles; reinforced foundations; foundations with layer of cork or felt.

Two-Cycle, Scavenging. The Size of Exhaust Ports in Two-Stroke Oil Engines (Die Bemessung der Auspuffschlitze bei Zweitakmaschinen), A. Scheibe. Werft-Reederei-Hafen (Berlin), vol. 9, no. 21, Nov. 7, 1928, pp. 425–430, 5 figs. There is no method, based upon details of equalization process, to determine point of exhaust-port opening relative to point of stroke at which scavenging should begin after certain pressure drop in cylinder has taken place; author outlines comprehensive investigation into question; method evolved is checked against test data from 15,000-b.hp. engine and satisfactory agreement found. See translated abstract in Mar. Engr. and Motorship Bldr. (Long.), vol. 51, no. 616, Dec. 1928, p. 473.

OPEN-HEARTH FURNACES

Design. The Economic Size of the Open Hearth. F. A. King. Min. and Met., vol. 9, no. 264, Dec. 1928, pp. 550–551. Discussion as to how big furnace can be operated successfully; experience with 300-ton furnaces at Weirton, W. Va. indicates that economic limit has not yet been reached. Paper presented at Open Hearth Conference, Pittsburgh, Pa.

P

POWER PLANTS

Cost Accounting in. Power Station Costing Systems, C. W. Marshall. World Power (Lond.), vol. 10, no. 55, Dec. 1928, pp. 609–612. Article presents system of cost accountancy which takes proper cognizance of physical aspects of electricity generation and establishes method of recording economic data to enable compilation of reliable and informative comparisons; capital costs of modern power station.

POWER PLANTS, DIESEL

Trends in. Representative Trends in Diesel Power Practice, R. C. Paul. Power Plant Eng., vol. 32, no. 24, Dec. 15, 1928, pp. 1337–1338, 2 figs. Increase in size and speed, decrease in unit weight, simplification of design and of control of operation and increase and refinement of auxiliary equipment are contemporary Diesel trends; rotative and piston speeds increasing; records and recording instruments; Diesel application widening.

POWER PLANTS, STEAM

Ash Handling in. Methods and Means for Conveying Ashes. Power Plant Eng., vol. 33, no. 1, Jan. 1, 1929, pp. 23–26, 9 figs. Handling ashes from furnace ash hoppers to storage bins involves consideration of ash gates, quenching methods, conveying equipment, ash cars and elevating equipment; ash prepared for handling in ash hopper; system for continuous conveying.

Coal Handling in. Coal Unloading Methods at Power Plants. Power Plant Eng., vol. 33, no. 1, Jan. 1, 1929, pp. 4–6, 6 figs. Grab bucket used to unload coal from barge to hopper, usually driven by hoisting engine or two motors of crane type; flat-bottom and hopper-bottom gondola cars used for unloading from cars; hopper car most popular because coal can be automatically discharged from car to track hopper which feeds conveying system or cars are run on elevated tracks and discharged directly to storage area; by this means no power is required and unloading is done rapidly; for delivering coal, trucks either of end-dump type or with coal gates and chutes which may discharge from either side or end, are used.

Drag Scrapers for Storage and Reclamation. Power Plant Eng., vol. 33, no. 1, Jan. 1, 1929, pp. 14–15, 9 figs. Simplicity of equipment and operation and low cost of installation are primary features that favor drag scrapers for coal handling; drag scrapers operate with same facility up or downhill, on wet, soft or submerged ground; they mix lumps and fines together, preventing air passage and thereby reducing fire hazard of coal in storage.

Developments in. Trends and Tendencies in Steam Plant Practice, H. D. Savage. Power Plant Eng., vol. 32, no. 24, Dec. 15, 1928, pp. 1297–1298. High steam pressures, steam-generating units of large capacity, and refinement of fuel-burning equipment constitute principal 1928 developments.

Heat Balance. Heat Balance Tends Toward Increased Extraction. Power Plant Eng., vol. 32, no. 24, Dec. 15, 1928, pp. 1314–1316, 14 figs. New stations use larger percentage of bled steam; use of evaporators almost universal; increased attention being given to deaeration of feedwater; many plants use both economizer and air heater.

High-Pressure, German. High-Pressure Plant of the Stettin Central Station (Die hochdruckanlage des Grosskraftwerkes Stettin), W. Heuelmann. Archiv fuer Waermewirtschaft (Berlin), vol. 9, no. 12, Dec. 1928, pp. 377–383, 10 figs. Notes on selection and size of boiler and machinery with details of design and results of acceptance tests; turbo-generator of 25,600

kw. was installed; half of boilers are equipped with traveling grates and other half with pulverized-coal firing; designed to generate steam at 35 atmos. and 400 to 425 deg.; operating experiences with pulverizers, boilers, etc., and cost data.

POWER PLANTS, STEAM-ELECTRIC

Standby and Peak-Load Service. Standby and Peak Load Service Furnished by Nashville Steam Plant Extension, H. H. Bailey. South. Power Jl., vol. 46, no. 12, Dec. 1928, pp. 46–52, 11 figs. New steam plant uses unit pulverizers, water-wall furnaces, air preheaters, and adjustable radiant-type superheaters; plant cares for peak loads in normal operations, base loads in time of low water, and local loads in time of emergency; space limitations exceptional; water and coal system extended to serve new units; ash disposal.

PRESSES

Design. Producing Deep Drawn Shells on Single Action Presses, C. W. Lucas. Metal Stampings, vol. 1, no. 7, Dec. 1928, pp. 529–530, 1 fig. Description of die for advantageously performing deep drawing operations in single-action presses.

PUMPING STATIONS

Diesel. Diesel-Geared Centrifugals for Urban Water Service, A. D. Couch and J. J. Garland. Oil Engine Power, vol. 6, no. 12, Dec. 1928, pp. 818–820, 3 figs. Direct-drive Diesel pumping station operated by New Rochelle Water Co. at Pocantico Hills, N. Y., is described; 2-stage DeLaval pump rated at 3 M. G. D. against head of 335 ft. is driven through DeLaval 8 to 1 step-up gear by 3-cylinder, 4-cycle air-injection McIntosh and Seymour Diesel engine rated at 338 hp. at 225 r.p.m.; details of speed-up gear.

PUMPS

Turbine, Theory of. Aerofoil Theory of Propeller Turbines and Propeller Pumps With Special Reference to the Effects of Blade Interference Upon the Lift and the Cavitation, F. Numachi. Soc. Mech. Engrs.—Jl., (Tokyo), vol. 31, no. 136, Aug. 1928, pp. 530–583, 4 figs. Writer has deduced theory of these machines in light of theory of airfoil; preliminary study of theory of blade interference; theory of propeller turbines and of propeller pumps. (In English.)

R

RAILROADS

Motor-Vehicle Competition in Great Britain. British Railways: The Next Step, P. A. Harverson. Modern Transport (Lond.), vol. 20, no. 505, Nov. 17, 1928, p. 4. Railroad position today; unfair that one form of transport should be subject to regulations while other can charge what rates it likes, pay whatever dividends it likes, and conduct all its transactions in secret; position of road transport; private car as serious menace to rail traffic; cheap fares discussed; feasibility of penny mile; frequent stops; what railways might do; railway idea of coordination. Abstract of paper read before L.N.E.R. Lecture and Debating Soc.

REFRACTORIES

Properties of. Some Properties of Refractories, J. B. Shaw. Blast Furnace and Steel Plant, vol. 16, no. 12, Dec. 1928, pp. 1610 and 1613. Data given on fusion temperature, resistance to load at high temperature, resistance to spalling, and resistance to slag for number of representative refractory materials; tables from article by F. H. Norton published in Journal of American Ceramic Society, vol. 8, no. 12; brown zircon, kaolin and silicon carbide have lowest coefficient of expansion; zircon, silicon carbide, and kaolin most resistant to spalling.

REFRIGERATING MACHINES

Gas. How the Gas Refrigerator Works. Domestic Eng. (Chicago), vol. 125, no. 10, Dec. 8, 1928, pp. 39 and 41, 3 figs. Electric machines accomplish refrigeration by means of compressor driven by electric motor; gas refrigerator makes use of small boiler to raise pressure of refrigerant; major steps in cycle of gas refrigerator; diagram showing principal parts of gas refrigerating machine.

ROCKET PROPULSION

Theory of. The Kinetic Theory of Gases, the Second Law of Thermodynamics, and Rocket Propulsion (Die kinetische Gastheorie, der zweite Hauptsatz der Thermodynamik und der Raketenantrieb), K. Baetz. Maschinen-Konstrukteur (Leipzig), vol. 61, no. 21, Nov. 1, 1928, pp. 498–505, 6 figs. Mathematical discussion of mechanical theory of rocket propulsion.

ROLLING MILLS

Blooming Mills, Transfer Tables for. Chain Transfer Tables for Blooms. Blast Furnace and Steel Plant, vol. 16, no. 12, Dec. 1928, pp. 1559 and 1570, 3 figs. Routing from shear to four distinct operations accomplished at new plant of Timken Steel and Tube Co. by chain transfer tables thus allowing special treatments necessary in production of alloy-steel blooms in quantity; design of transfer table and operating control are discussed.

Cold-Rolling Strip Mills. Employs Individual Drives for Cold Strip Mill Stands. Iron Trade Rev., vol. 83, no. 25, Dec. 20, 1928, pp. 1560–1562, 4 figs. Description of new pickle, galvanizing and cold-roll strip plant of Sharon Steel Hoop Co.; from pickle storage strips are fed through pickle shop; complete cold-roll equipment; three sets of tandem roughing mills; seven sets of finishing mills; pinch rolls serving tandem cluster units facilitate feeding coils to first pass; variable-speed motors permit adjustment of tension; box annealing furnaces.

Electric Drive. Studies of Power Requirement in Continuous Rolling Mills With Electric Drive (Kraftbedarfsstudien in durchlaufenden elektrisch angetrieben Walzentrassen), A. Werth. Archiv fuer das Eisenhuettenwesen (Duesseldorf), vol. 2, no. 5, Nov. 1928, pp. 301–308, including discussion, 16 figs. Notes on differences in power requirement of mills of similar cross-sections; explanation of term, specific productive rolling work (bezogene Lastmehrarbeit), by which is understood that work that roll motor has to perform in excess of work at no-load; results of tests. See abstract in Stahl u. Eisen, vol. 48, no. 48, Nov. 29, 1928, pp. 1670–1671, 3 figs.

The Electric Driving of Rolling-Mills. Mech. World (Manchester), vol. 84, no. 2186, Nov. 23, 1928, pp. 492–493, 4 figs. General description of electric-drive requirements in rolling mills precedes details of new electrically driven plant recently installed by Appleby Iron Co.; direct drive most suitable form for non-reversing mills; special types of starters; speed regulation of driving motors; special types of motors built for reversing rolling mills; switchgear.

European Practice. Rolling Thin Sheets, W. Kramer. Rolling Mill Jl., vol. 2, no. 12, Dec. 1928, pp. 527–530. Methods for overcoming difficulties of rolling thin sheets; prevention of sticking; cold rolling of special sheets; improvements in cold rolling mills. Translated from Stahl u. Eisen.

Roll Heaters. Electric-Induction Roll Heaters. Foundry Trade Jl. (Lond.), vol. 39, no. 644, Dec. 20, 1928, pp. 453–454, 7 figs. In order to insure that rolls of tinplate shall be cylindrical during normal rolling, new methods have been devised; principle of this method of roll heating consists of surrounding pair of rolls with coil of wire through which flows alternating current; this induces currents in mass of metal contained in rolls, so generating heat therein; thus difficulty of rolls being hotter at center of their surface is counteracted.

S

SHEET METAL

Welding. Oxyacetylene Welding of Light Gage Sheets by Simple Mechanical Methods, H. J. Grow. Am. Welding Soc.—Jl., vol. 7, no. 12, Dec. 1928, pp. 14–26, 11 figs. Development of mechanical welding; functions of jigs in welding; design of jig from heat-absorption standpoint; application of mechanical welding; strength of mechanical gas welds; tube welding; types of gas welds other than butt welds.

SPRINGS

Laminated, Research on. Researches on Springs—the Effect of "Nip" on the Mechanical Properties of Laminated Springs. R. G. Batson and J. Bradley. Dept. of Sci. and Indus. Research—Special Report (Lond.), no. 11, 1928, 37 pp., 26 figs. It is sometimes practice to vary curvature of individual plates of spring in such a way that when leaves are placed on one another there are gaps between them; springs made in this way are said to have been given "nip;" advantage of "nip" is that, if it is adjusted correctly, master leaf when under repeated loadings has zero mean stress and is in its most favorable condition for resistance to repeated stresses.

Monel-Metal. Monel Metal Springs for High Temperature. G. V. Pickwell. Inco, vol. 8, no. 3, 1928, pp. 10–11 and 20, 3 figs. Effect of high tmperature on perfomance, hardness and strength of springs made of Monel Metal; purpose of this article is to formulate from experimental data guide for use of springs made of Monel Metal when operating at elevated temperatures; mechanically superior to all other metals under conditions of elevated temperature; does not corrode as readily under those conditions; Monel Metal should be used advisedly and within range where loss of strength can be held down to minimum.

STEAM

High-Pressure. Application of High-Pressure Steam (Zur frage der Anwendung des Hochdruckdampfes), Loschge. Zeit. des Bayerischen Revisions-Vereins (Munich), vol. 32, nos. 21 and 22, Nov. 15, and 30, 1928, pp. 285–289 and 299–301, 14 figs. Author discusses problems of application of high-pressure steam and extent to which it is applicable and important in industry.

STEAM ENGINES

Valve Gears. A Noteworthy Design of Reversing Valve Gear, J. T. Marshall. Colliery Eng. (Lond.), vol. 5, no. 58, Dec. 1928, p. 482, 3 figs. Description of new type designed by J. T. Marshall; basis of gear is mechanism of normal type, but slotted link is called into play only for reversing and is not acted upon by governor; normal slide or piston valve is replaced by main steam valve which is concerned only with admission.

STEAM PIPE LINES

Pressure Losses in. Pressure Loss in Steam Pipe Lines With Regard to Heat Absorption or Emission Through Pipe Wall (Der Druckverlust in Dampfleitungen mit Beruecksichtigung der Waermeaufnahme oder-abgabe durch die Rohrwand), P. Koh. Waerme (Berlin), vol. 51, no. 47, Nov. 24, 1928, pp. 861–863, 1 fig. Volumetric change of flowing steam influences pressure loss; derivation of simple ratio based on this factor; graphical presentation.

STEAM TURBINES

Blades, Testing. Fatigue Strength of Steam Turbine Blades. Iron Age, vol. 122, no. 26, Dec. 27, 1928, p. 1625. Brief description of study of turbine blading made by Moore, Lyon, and Alleman, University of Illinois Engineering Experiment Station, for Allis-Chalmers Mfg. Co.; short lengths of blades mounted in special chucks and rotated under load until failure developed from alternating bending stresses; numerical results for cupro-nickel, monel, and cyclops metal blades shown in Table. From Bul. No. 183.

Germany. The Turbines at the Klingenberg Power Station. Engineer (Lond.), vol. 146, nos. 3804 and 3805, Dec. 7 and 14, 1928, pp. 620–622 648–651, 19 figs. partly on supp. plate. Station of Berlin Electricity Co., is noteworthy, not only for its size, but as representing latest Continental practice in superstations; main units supplied by A.E.G.; each consists of turbo-generator of maximum capacity of 80,000 kw., and house turbine of 10,000 kw.; steam flows in opposite directions through high-pressure and intermediate-pressure cylinders, and through two low-pressure cylinders; axial balance is thus secured on both sides of turbines.

High-Pressure. High-Pressure Steam Turbines (Hoechstdruckturbinen), E. A. Kraft. Brennstoff und Waermewirtschaft (Halle Saale), vol. 10, no. 17, Sept. 1, 1928, pp. 321–327, 6 figs. General principles and characteristics with special reference to turbines made by Brown-Boveri, General Electric, De Laval, A.E.G., Escher Wyss, etc.

Testing. Simple Method of Applying the Odqvist Calculating Method in Measuring Steam with Throttle Flange (Enkel metod att tillampa odqvist ska beraknings sattet vid angmatning med strypflans), A. Meldahl. Teknisk Tidskrift (Stockholm), vol. 58, no. 46, Nov. 17, 1928 (Mekanik), pp. 142–143, 4 figs. Formula and curves developed at Svenska Turbin Fabrik of Ljungstrom for testing of back-pressure turbines, checking of results against old method.

STEEL

Automobile, Cutting Speeds for. Standardized Materials in Automobile Manufacture and Their Preparation (Die genormten Werkstoffe des Kraftfahrbaues und ihre Bearbeitbarkeit), A. Wallics and K. Krekeler. Motorwagen (Berlin), vol. 31, no. 34, Dec. 10, 1928, pp. 832–836, 6 figs. Experimental values are given of cutting speeds to which different standard steels can be subjected under certain cutting conditions; results so far obtained afford good insight into machinability of German standard steels.

Hardening. Recent Investigations of the Theory of Steel Hardening (Neuere Untersuchungen ueber die Theorie der Stahlhaertung), E. Scheil. Archiv fuer das Eisen huettenwesen (Duesseldorf), vol. 2, no. 6, Dec. 1928, pp. 375–387 and (discussion) 387–388, 39 figs. Conver-

sion of austenite into martensite; influence of pressure and stresses; change of austenite with annealing; determination of austenite content; Maurer's hardening hypothesis; influence of grain size on hardness; hypothesis of Smekal and Hanemann; austenite-martensite diagram of state.

STEEL CASTINGS

Large. A Very Large Steel Casting. Engineer (Lond.), vol. 146, no. 3797, Oct. 19, 1928, p. 442, 2 figs. What is believed to be largest steel casting yet made has been completed by Cammell Laird and Co., Ltd., of Sheffield; combined haulage capacity of five road engines was required to transport it; casting is anvil block for friction drop stamp designed for use with 5-ton tup.

Molding Methods. Steel Castings from Moulder's Viewpoint, J. Jefferson. Foundry Trade Jl. (Lond.), vol. 39, no. 641, Nov. 29, 1928, pp. 393–394, 3 figs. Simple tests were carried out and following summary is given: designed dimensions must be adhered to; material must be everywhere homogeneous; it must be free from internal cavities, from cracks and from porosity; internal stresses must be reasonably absent; founder cannot do more than attempt to correct by annealing; reduction of thickness. Paper presented before joint meeting of Inst. Brit. Foundrymen and Inst. Mech. Engrs.

Requirements. A Symposium on Steel Castings—Admiralty Requirements and X-Ray Investments, Sedgwick. Foundry Trade Jl. (Lond.), vol. 39, no. 639, Nov. 15, 1928, pp. 357–358 and (discussion) 359. Admiralty requirements for material to be suitable for production of castings to stand up to superheated steam; specifications for machinery castings; general characteristics of failures: blow-holes, draws, porosity under pressure tests, contraction cracks, sand inclusions, scabbing and failure on physical tests; danger of laxity in patching; examination of castings by X-rays and by magnetic methods is being rapidly developed.

STRENGTH OF MATERIALS

Theory of. Principles of the Theory of Strength of Materials (Die grundlagen der theoretischen Festigkeitslehre), M. Ensslin. V.D.I. Zeit. (Berlin), vol. 72, no. 45, Nov. 10, 1928, pp. 1625–1634, 18 figs. Paper read at 1927 annual meeting of German Society for Testing Materials; discussion of ultimate strength from points of view of engineering and physics, ultimate strength in impact repeated stresses and under static load; ideal and imperfect state of engineering materials; single crystals; results of recent experiments for testing of theories of strength of materials compared with those obtained by Guest in 1900.

STROBOSCOPES

Stroborama. The Stroborama, New Stroboscopic Apparatus with Strong Lighting, Its Industrial Applications (Le stroborama, nouvel appareil stroboscopique à grand éclairage, ses applications industrielles), L. Seguin and A. Seguin. Assn. des Ingénieurs Electriciens Sortis de Institut Electrotechniéue Montefiore—Bul. (Liège), vol. 6, no. 8-9, Aug.-Sept. 1928, pp. 137–156, 3 figs. Review of stroboscopic apparatus; defects of former designs; applications of stroborama to automotive engines, hydraulics, aerodynamics, general mechanisms, and other machinery; speed measurements; spinning mills; stroboscopic curves.

STRUCTURAL STEEL

Arc Welding of. Arc-welding Steel Structures and Machine Parts. Machy. (Lond.), vol. 33, no. 840, Nov. 15, 1928, pp. 208–209, 7 figs. Advantages of arc-welding steel structures and machine parts are discussed; additions made to laboratory building and penthouse for elevator at one Westinghouse plant briefly described.

Flame Cutting. Flame Cutting of Structural Steel, S. W. Miller and J. R. Dawson. Can. Engr. (Toronto), vol. 56, no. 3, Jan. 15, 1929, pp. 151–152. Results of tests indicate that flame cutting does not injure structural steel when suitable machine is employed; tension and bend tests; wind braces and copings. Paper presented before Am. Inst. Steel Construction.

SUPERHEATED STEAM

Specific Heat of. Specific Heat of Superheated Steam (Die spezifische Waerme des ueberhitzten Wasserdamfes), O. Knoblauch and W. Koch. V.D.I. Zeit. (Berlin), vol. 72, no. 48, Dec. 1, 1928, pp. 1733–1739, 15 figs. Report from laboratory of engineering physics of Munich Institute of Technology presenting results of 62 determinations at constant pressures ranging from 30 to 12 atmos. at saturation temperatures up to 450 deg. cent.; platinum-wire resistance thermometer was used.

T

TAPER SHANKS

Standardization of. Taper Shank Standardization, T. Fish. Machy. (N. Y.), vol. 35, no. 3, Nov. 1928, pp. 210–212, 2 figs. Advantages and disadvantages of three taper shanks in general use are described with outline of origin and present applications; Ready Tool Co. investigated standardization of taper shanks in connection with manufacture of high-speed centers: large savings which would result are realized; greater interest needed in standardization; author's work on proposed standard taper and comparison with Morse Taper; present sleeves and collets changeable at slight expense.

TOOLMAKING

Production Control in. Systematic Tool Production With Classified Costs, G. H. Bitzer. Am. Mach., vol. 69, no. 19, Nov. 8, 1928, pp. 740–742, 6 figs. By means of system described, tool production in Westinghouse Electric and Mfg. Co. is kept on even schedule and classified costs are gathered; how tool order originates and subsequent steps in building tool with cost-accounting methods used, are outlined; department turns out 300 new dies and fixtures and handles 250 repair jobs a month.

TOOL STEEL

Tungsten Carbide. Carboloy and Tungsten Carbide Tools, S. L. Hoyt. Am. Soc. Mech. Engrs.—Advance Paper, no. 15, for mtg. Dec. 3–7, 1928, 4 pp. Author points out that economic value of carboloy (trade name adopted by General Electric Co. for such material), is so great in many instances that it at once justifies its use; tungsten carbide may be classed as one of hardest materials, coming just below diamond and its has metallic rather than non-metallic nature; art of utilizing tungsten carbide as in its infancy; time and experience alone can teach how it is to be handled and how to delimit accurately scope of its applications.

TRAIN CONTROL

United States. Train-Control Systems in the United States (Die Zugbeeinflussungsysteme bei den Eisenbahngesellschaften der V. S. Amerika), A. Kammerer. Elektrotechnische Zeit. (Berlin), vol. 49, no. 27, July 5, 1928, pp. 1005–1009, 8 figs. Railroad companies of United States are constrained by law to install and maintain on larger lines train-control equipment of train-stop or indicator type; in "continuous" or "track control" alternating current passed along track rail influences receiver coil on locomotive; this is used in conjunction with track circuiting; two methods are fully described.

TUBES, STEEL

Cold-Worked. Tests of Metal in Cold Pressed Tubes, R. W. Miller. Heat Treating and Forging, vol. 14, no. 10, Oct. 1928, pp. 1162–1163, 8 figs. Since cold working of metals changes their physical properties, tests were made to ascertain possibility of subsequent annealing of tubes in order to obtain properties of metal in its original state; the annealing was done successfully at a temperature of 850 deg. cent., after the completion and welding of tube.

TURBO-COMPRESSORS

Design. A Contribution to the Design of the Turbo-Compressor, M. Maekawa. Soc. Mech. Engrs.—Jl. (Tokyo), vol. 31, no. 136, Aug. 1928, pp. 467–504, 7 figs. Formulates compression curve; gives comparison both of theory and experiments; determination of two casings having intercooler; includes hydraulic efficiency of each stage in multi-stage turbo-compressor. (In English.)

V

VISCOSIMETERS

One-Motion-Control. One Motion Control Viscosimeter. Instruments, vol. 1, no. 11, Nov. 1928, pp. 493–494, 1 fig. New Teschner instrument is claimed to be conspicuous advance in viscosimeters of Saybolt type; it extends precision mechanical control to each of important factors of test; strict coordination between flow of oil and stop watch is achieved by straight rod; called one-motion viscosimeter because one motion starts or stops flow of oil and stop watch simultaneously.

W

WAGES

Bonus Systems. Analysis of Principles Involved in Task Work With Bonus, W. N. Polakov. Am. Mach., vol. 69, nos. 20 and 21, Nov. 15 and 22, 1928, pp. 753–754 and 811–813. Nov. 15: First part of logical study of management principles in which unusual step-by-step method of developing subject is employed; individual ability; instructions and training of workmen taken up. Nov. 22: Task and reward are considered; by means of definite task with bonus for its attainment, cost per unit of product tends toward lower level, supervision is simplified, and cost easily allocated.

York Bonus Wage System, Comparison With the Towne-Halsey and Rowan Systems (Le salaire à prime York, Comparison avec les systèmes Towne-Halsey et Rowan), J. Chevalier. Geénie Civil (Paris), vol. 93, no. 22, Dec. 1, 1928, pp. 522–523, 2 figs. Comparison of bonus systems of wage payments; hourly wages and cost of unit of work in the Towne-Halsey and Rowan systems; York system is discussed.

Incentive Plan. Introducing an Incentive Plan, P. H. Cone. Iron Age, vol. 122, no. 24, Dec. 13, 1928, pp. 1495–1496. Description of wage incentive system of Dyer type wherein total number of minutes of every employee's time is accounted for; care must be taken to gear up plant and personnel to new wage method; how to overcome resistance of workmen; success of plan may require changes in processes; program stresses common interests of management and men. Abstract of paper presented at Nat. Assn. Cost Accountants.

WELDING

See ALUMINUM; BOILER TUBES; ELECTRIC WELDING; SHEET METAL.

WIRE

Steel, Properties of. Heat Treatment of Steel Wire, S. H. Rees. Fuels and Furnaces, vol. 6, no. 12, Dec. 1928, pp. 1735–1736. Effect of low-temperature heat treatment on mechanical properties and on microstructure low-temperature heat treatment of wire under stress. Abstract of paper presented before Iron and Steel previously indexed from Iron and Coal Trades Rev., Sept. 28, 1928.

WIRE-FORMING MACHINES

Types. Equipment Principles for Making Formed Wire Parts, F. H. Mayoh. Am. Mach., vol. 69, no. 21, Nov. 22, 1928, pp. 797–800, 9 figs. Demands for quantity production of intricate articles formed of wire have led to development of special machines that can be adapted readily to making of various parts by changes in tools and attachments; principle of operations of straightening machines; wide choice of applications may be had on four-slide type of wire-forming machine; chain in wide variety of shapes is made on modified types of slide and plunger wire-forming machines.

WOODWORKING MACHINERY

Ball Bearings in. Ball Bearings as Applied to Woodworking Machinery, H. E. Brunner. Am. Soc. Mech. Engrs.—Advance Paper, no. 8, for mtg. Dec. 3–7, 1928, 9 pp., 14 figs. Principles underlying practice which is generally followed are brought out by descriptions of actual bearing installations; special considerations entering into design and manufacture of bearings for this field are discussed; question of lubrication is considered, and requirements of lubrication peculiar to anti-friction bearings are discussed in detail.

Chucks, Use on. The Application of Universal Chucks to Woodworking Machinery, A. E. Englund. Am. Mach., vol. 69, no. 25, Dec. 20, 1928, pp. 969–970. Application of universal chucks to boring and routing machines, lathes, and combination woodworking machines is described; universal chuck very essential equipment on woodworking lathe, and is used to great advantage in both headstock and tailstock. Abstract of paper presented before Am. Soc. Mech. Engrs.

Spindles, Lubrication. Lubrication of Ball-Bearing Woodworking Spindles, H. R. Reynolds. Am. Soc. Mech. Engrs.—Advance Paper, no. 26, for mtg. Dec. 3–7, 1928, 3 pp., 8 figs. Paper brings out methods of lubrication especially suitable for speeds of 4000 to 7500 r.p.m. which is about range of woodworking spindles; where oil is used its level should not be over center of lowest ball if speeds are higher than 500 r.p.m.; at 5000 to 5700 r.p.m. very light spindle oil should be used; too much oil should not be used as it will cause heating, and the higher the speed the greater the heat; failure is generally due to dirt, so bearings must be kept clean.

In Two Sections—Section Two

MECHANICAL ENGINEERING

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What It's All About

THE interests of the engineer lie in the present and the future, just as those of the historian lie in the past. Modern machines and methods do not wear out; they become obsolete. Engineers have given to obsolence an acute significance. Not to be up to date is one of the cardinal sins of engineering.

MECHANICAL ENGINEERING takes particular pains to keep its readers up to date. Every month it gives them something new to think about: ideas gleaned from the world's engineering literature, original contributions on topics of broad interest, pithy items indexing a month's progress.

This supplement to MECHANICAL ENGINEERING attempts a brief review of its contents. Frankly, the idea is not to make it unnecessary to read the original articles, but to convince you that you should read them. And before this single sheet is lost, pass it on to some one else. It will surprise him to know what a variety of subjects interest the engineer; and he will think better of your profession for reading it.

Kilo Man-Hours

YOU may as well learn this term now, because it will soon be as common as kilowatt-hours, and when some one asks you about it, it would be embarrassing to confuse it with an electrical unit. Besides, the financial journals, the newspapers, and *The Literary Digest* have been talking about it.

The idea is quite simple. If a factory is making shoes, or typewriters, or textiles, or automobiles its productivity might be expressed in pairs, or machines, or yards, or taxicabs produced for every thousand man-hours worked. It is so simple that at first there seems to be nothing to it but another ratio of two dissimilar units which cannot possibly yield a pure number. But like any statistical index number, the value lies in comparisons. What would you say, for instance, if you found that the company in which you owned stock made a certain article with the expenditure of three kilo man-hours and a competitive concern made the same article with two? Or how would you feel if you were the manager of the company and your board of directors asked you to explain this discrepancy? This simple unit becomes a valuable measure of the efficiency of management. Messrs. Alford and Hannum, whose paper is the leading article in the March issue of MECHANICAL ENGINEERING, explains the kilo man-hour, and from the statistics of many industries which they have studied they point to some interesting comparisons. In *The Literary Digest* for January 26 comments from prominent engineers, the press, and financial journals on the significance of this new unit as a continuous measure of the fruitfulness of industry are summarized.

Wasps and Whirlwinds

MORE than one hundred years ago Sir George Cayley pointed out that one of the chief deterrents to mans' ability to fly in heavier-than-air machines was his lack of a motor sufficiently light for its power, and he made a suggestion that perhaps some form of internal-combustion engine, then unknown, would offer more attractive possibilities than did the steam engine.

Many attempts at aerial flight were made in the hundred years following Sir George Cayley's original work in 1809, and several motors were designed and built, but modern aviation owes its success to the development of the gasoline engine, and to the genius of the men who were able to adapt this type of motive power to the severe service of safely sustaining the flight of an airplane. In the March issue of MECHANICAL ENGINEERING, Charles Lawrance, whose name is so intimately connected with the famous "Whirlwind" engine, reviews the development of aeronautical engines in America. He writes with the sincere admiration of a fellow-engineer and craftsman of the notable contribution of Charles Matthews Manly, whose "gumption" and genius achieved as early as 1902 an engine of the radial type, which, except for the fact that it was water cooled rather than air cooled, was a startlingly modern first guess at what is today an approved and popular type. This engine, which was used in the ill-fated "Aerodrome" of Langley in 1903, is now in the Smithsonian Institution. Photographs of Manly's engine, and of the engine with which the Wrights made their flight at Kitty Hawk in 1903 are shown in contrast with such modern engines as the "Whirlwind" and the "Wasp."

Agricultural Problems

MODERN civilization has always had an agricultural problem. It exists no less in Soviet Russia where there is one pair of shoes for every four persons, than in the United States when there is one automobile for every four persons. It has frequently confronted statemen and politicians. In the recent presidential campaign it was a major issue.

Engineers naturally feel somewhat of a responsibility in this problem for several reasons. Engineers initiated the modern industrial age which has developed the city and drained the rural districts of their resources, providing markets, but not always profitable ones. Engineers have provided means of transportation which, while opening the way to more distant markets, have also opened them to a wider competition. Engineers have provided the machinery whereby toil is lightened and more acres are harvested per man—and the fertilizers which have increased the yield per acre.

It is natural, therefore, that engineers should seek a solution to an age-long problem which their own genius has complicated. Their method of attack, however, is